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JANUARY • 1951

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS


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AGRICULTURAL ENGINEERING

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Vol. 32, No. 1

INDEX TO ADVERTISERS

AGRICULTURAL ENGINEERING is owned, edited, and published monthly by the American Society of Agricultural Engineers. The editorial, subscription and advertising departments are at the executive office of the Society, Saint Joseph, Michigan.

OFFICERS AND COUNCIL OF THE A.S.A.E.

SUBSCRIPTION PRICE: $4.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to ASAE members anywhere, $2.00 a year. Single copies (current), 40 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

AGRICULTURAL ENGINEERING is a member of the Audit Bureau of Circulations.

ADVERTISING REPRESENTATIVES

Chicago 2: DWIGHT H. EARLY
100 North LaSalle St.
Tel. CEntral 6-2184

New York 17: BILLINGSLEA & FICKE
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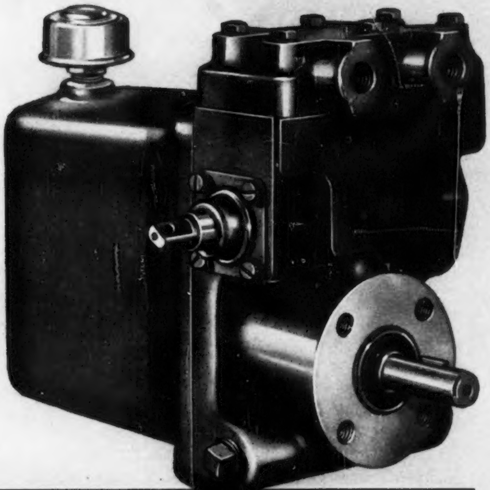

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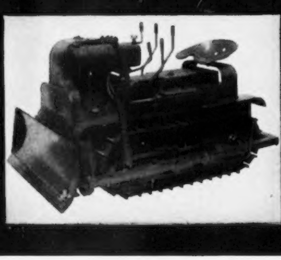

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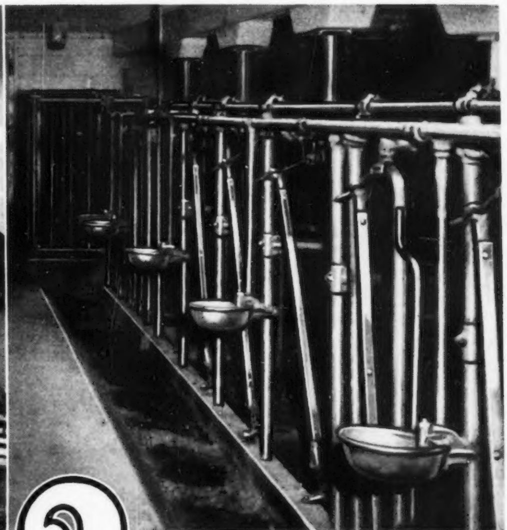

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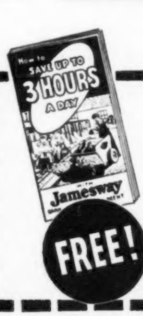

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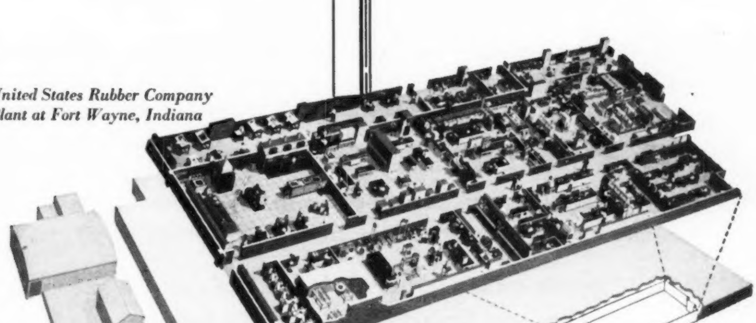

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EDITORIAL

Mobilization Responsibilities

SEVERAL members of the American Society of Agricultural Engineers have expressed concern that it avoid being guilty of doing "too little, too late" in the increasing mobilization of resources for defense.

Some of these same men, and others, have also foreseen a possible danger of the Society straying, in a burst of professional pride and patriotic enthusiasm, far from its most appropriate and effective field of usefulness.

The question is as to what the Society can and should do as a group, in addition to what its members can and will do individually.

At the present stage of mobilization against a threat of unmeasured proportions, members will naturally have a wide variety of ideas as to what the Society can and should contribute to national defense. It seems desirable that they give the matter further consideration, in the interest of working toward a stronger unity of viewpoint on principles and objectives. This could point the way to substantial agreement on specific action.

As a premise, we submit that the nature and objectives of the Society are not changed by emergency conditions. Relative emphasis on specific activities to carry out its objectives may be changed considerably for the duration.

It must be remembered that the Society is a voluntary association of professional men, each with his own full-time employment and professional responsibilities. Its purpose is service. Its approach is professional. It can serve the interests of its members only by serving the public interest. It can not properly represent any other than the public interest. It must avoid being tempted or deceived into being used for anything not in the public interest.

Its purposes and methods are not political. It lacks the numbers, as well as the desire, to be an effective pressure group. It lacks the financing, facilities, and personnel to undertake on its own any major defense projects. Its technology, however important, is only a part of that needed for effective mobilization.

The professional nature of the Society suggests that it may render its greatest emergency service in advisory and coordinating capacities within its technical field.

This defines but does not limit its opportunity for service. Under the pressures of mobilization the United States and its allies will need, more than ever, the counsel of men trained to think and work accurately in terms of physical realities.

In matters of engineering relating to the mobilization of agricultural resources, production facilities, production efficiency, and man power; in connection with the storage, handling, and processing of farm products; and in questions as to the most effective use of agricultural engineers as scarce specialists, some of that counsel might best be supplied by the Society and its representative working committees.

The Society and many of its individual members are experienced coordinators and cooperators. Their familiarity with farming, the agricultural sciences, and engineering should prove particularly helpful to the correlation of numerous defense production and control activities.

There will be occasion to take the initiative in making the nature and functions of agricultural engineering known to powers not yet familiar with this professional field. This will require considered judgment to avoid either overstating or understating its capabilities.

The Society's capacity to serve will depend on the extent to which it merits and gains acceptance as a ready, unbiased, objective source of accurate information and interpretations in its technical and professional field; and as an effective aid to coordination and cooperation between related mobilization activities.

This viewpoint is submitted not as dogma, but as a possible stimulus to further thought on the subject by members.

Accredited Curriculums

THE postwar accrediting program of the Engineers' Council for Professional Development has indicated substantial progress in agricultural engineering education. Fifteen professional curriculums have been accredited.

This greatly increases the opportunity for qualified young men to obtain engineering education measuring up to an accepted standard, with specialization in agricultural engineering.

In addition its signifies the growing acceptance, within the older branches of engineering, of the idea that agriculture is a field for engineering application amply justifying specialized professional training and practice.

Achieving this recognition has required concentration on providing a sound foundation of engineering training. Effective specialization in agricultural engineering will also require concentration on developing in the student an adequate appreciation of the field of application.

How this appreciation may best be developed in a curriculum necessarily loaded with engineering subject matter, seems likely to remain an open question for at least several years.

How large and detailed a body of agricultural subject matter must be superimposed on the engineering subject matter requirement?

In the current rapid development of agriculture and agricultural science, what is worth teaching the agricultural engineering student as significant fact, and what might best be identified to him as holdover practices, traditions, expedients, indications, boundaries of knowledge, and remaining unknowns?

Can agricultural science be taught in a manner to give the agricultural engineering student a particularly strong appreciation of the physical or engineering factors involved in the organic sciences? Or of biological factors influencing the physical nature of agricultural operations?

To what extent can the teaching of engineering science and methods include teaching of agriculture by using specially selected examples, exercises, and problems?

Various schools, agricultural engineering departments, and individual teachers will undoubtedly work out the answers to these and other questions in a variety of ways, with generally good results. We look forward to continuing progress in agricultural engineering training, both in basic engineering and in the foundation provided for its application in the service of agriculture.

Registration Favored by Employers

REGISTRATION of engineers is advantageous to the public, to the engineering profession, and to employers of engineers. It is helping to raise standards of engineering practice and to gain public recognition of the engineering profession.

This, in substance, is the majority opinion of more than 100 large employers of engineers as expressed to the Committee on Effects of Registration for the National Council of State Boards of Engineering Examiners. The employers' representatives furnishing the information were, in most cases, not engineers. A summary of the study was recently reported editorially in *The American Engineer*, monthly journal of the National Society of Professional Engineers.

A substantial majority of the employers further indicated that they encourage the registration of engineers in their organizations, but that they do not require registration or favor engineers who are registered in their employment of engineers.

In other words, a majority of these employers apparently feel that registration of engineers is a good thing which engineers themselves should recognize, get in on, and work to strengthen largely on their own individual initiative and without compulsion. We leave it to individual agricultural engineers to draw their own conclusions.

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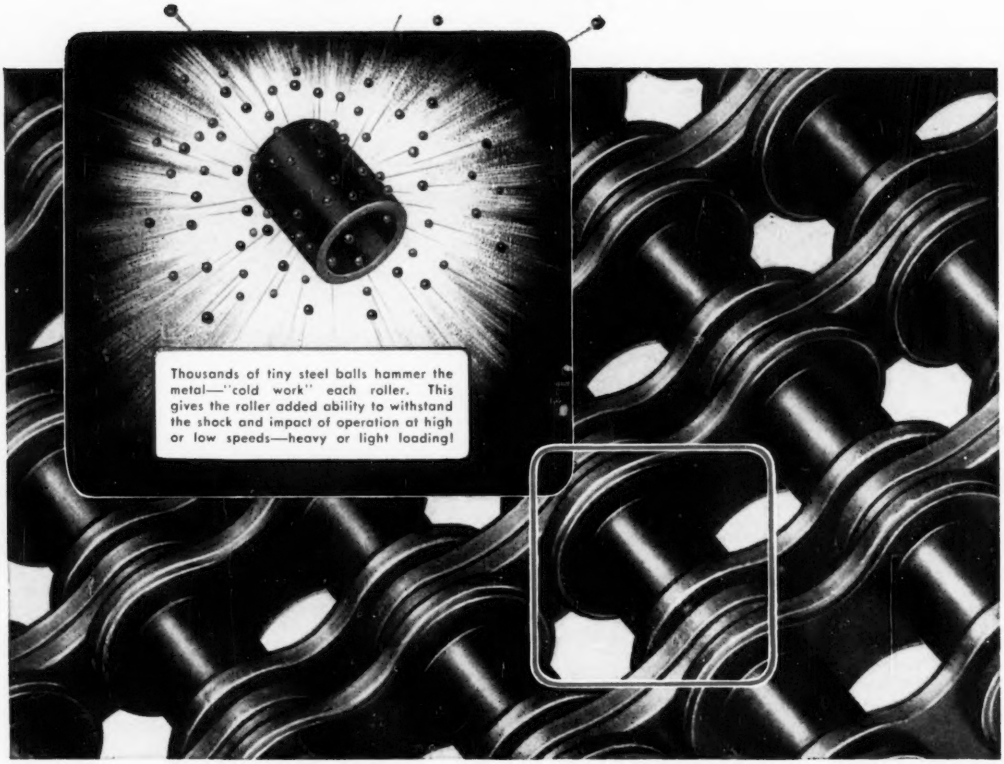

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AGRICULTURAL ENGINEERING

VOL. 32 | JANUARY, 1951 | NO. 1

The Training of a Farm Implement Designer

By Russell R. Raney
MEMBER A.S.A.E.

ANY pertinent observation on the training of a farm implement designer is bound to be concerned with the engineering colleges on the one hand, and with the farm implement industry on the other. I would, therefore, like to make it clear at the outset that I have attempted to take a neutral position with regard to the particular interests of each of these institutions. I have, to the best of my ability, reached my conclusions in the interest of what must be, for all of us, the one logical and ultimate benefactor—American agriculture.

My discussion is divided into four parts. In the first part I will describe the attributes of the ideal farm implement designer for the purpose of setting up a well-defined goal. In the second part, I will classify the candidates for this goal according to the type of preliminary training which they have received. Thirdly, I will discuss a process which is in common use today for bridging the gap between the preliminary training and the ultimate goal of a farm implement designer. And in the fourth and concluding part I will present two propositions for narrowing the gap and for hastening the process by which the gap is bridged.

Attributes of the Ideal Farm Implement Designer. For the purpose of this paper, I will assume the ideal farm implement designer to be a person having a knowledge of mechanical-engineering techniques, a knowledge of structural and agricultural materials, a knowledge of manufacturing processes, some creative ability, and a faculty for thinking analytically. I am perfectly aware that real engineering departments are composed of individuals who, for the most part, have only a partial command of these various fields, but they are usually integrated in such a way as to complement each other in carrying on the work as a whole. But where the matter of training is being considered, we cannot settle for anything less than the ideal as a basis for discussion in order to cover the entire range of possible needs. So that we may be perfectly clear about the exact nature of these needs, I shall elaborate upon each of them in turn.

By the term "mechanical-engineering techniques", I mean to include as a minimum the application of the fundamental laws of mechanics to the solution of the various force problems which make up the bulk of any mechanical design. Whether the solutions be reached by inspection and intuitively or by formal measurement and mathematical analysis, no one can qualify as a designer without first having the ability to predict the stresses and reactions which arise from various static and dynamic force systems. The degree of refinement which is required in these techniques is directly related to the complexity of the problems with which the designer is confronted. And when we confront him with the entire field of farm implement design which includes everything from peg-tooth harrows to cotton pickers, the ideal designer should be armed with an equally wide range of tools — from pocket tape measure to electric strain gages — from good eyesight to high-speed photography — and from simple mathematics to differential equations.

In the realm of structural and agricultural materials, the designer must be familiar with the physical characteristics of the materials used to withstand the stresses and reactions which have been determined by applying the mechanical-engineering techniques. For the most part, this involves a knowledge of iron and steel which appear to be the preponderant materials used in making all kinds of farm implements, regardless of their complexity. Some acquaintance with the commercially available forms of these materials is also helpful in this connection. But, in addition to a knowledge of structural materials — and this is the thing which makes the farm implement designer a very special kind of mechanical engineer — the ideal man must have a first-hand appreciation of the physical characteristics of a wide range of farm crops and soils. Most of my listeners know well enough what a variety of physical characteristics one crop alone may exhibit in its various stages. It is not surprising, then, that a knowledge of many crops involving many conditions is not frequently found in the possession of any one man. Instead, the designer tends to gather specialized knowledge about one particular crop and its geographical variations.

A contributing factor in this connection is the fact that for each problem involving a knowledge of the crop in a given machine, there are many problems of a mechanical nature which have no relation to the crop characteristics. A relatively small knowledge of agricultural materials may, therefore, be sufficient for a designer to carry on an extended machine-development program which, while adding greatly to his engineering experience and knowledge of structural materials, may not add at all to his appreciation of other crop conditions.

When the designer has joined his engineering technique to his knowledge of agricultural and structural materials, he is then faced with the problem of translating the design into some structural form which is easily reproducible in quantities and at a price within reach of the prospective user. This involves the selection of as many standard and commercially available components as possible such as chain, sprockets, knuckles, bearings, belts, gears, etc., and then to design the remaining non-standard components in such a form as to lend themselves to being manufactured on the facilities which the man's employer may happen to possess. In small firms, these facilities may consist only of a cutting torch, a drill press and an arc welder. In large firms, however, the designer must not only comprehend, but design intelligently for shears, presses, bulldozers, drop hammers, automatic lathes, boring mills, spot welders, arc welders, butt welders, milling machines, grinders, and last but far from the least in importance — grey iron and malleable foundries. In addition, he should have a good perspective on the relative cost of the special tools, jigs, fixtures, patterns, and gages used with each of these methods and be able to relate these costs to the expected volume of production for a given design. While the efficient use of these facilities is obviously quite necessary to the earning of a profit for the owner, there is another, more profound reason for this attention to quantity production facilities which merits our consideration. It is that agriculture, because of the extensiveness of the land, is, and always has been, a multiple-unit operation where the tools of crop production are concerned. Tilling the soil in this and every other country requires many tractors, many plows, many harrows, many seeding machines and many harvesting machines — each unit, relatively speaking, being determined in size by the limitations of one or two men to operate and service them. Hence, the desirability of easily reproducible farm implement designs is no less valid in

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Washington, D.C., June, 1950, as a contribution of the Power and Machinery Division.

The author: RUSSELL R. RANEY, chief engineer, advanced engineering at McCormick Works, farm implement division, International Harvester Co., Chicago.

Russia than in this country or any other nation regardless of the nature of its economic system.

Returning to the qualifications of the ideal farm implement designer, we now approach the particular faculty which utilizes and exploits the various funds of knowledge just described and which is probably the most important single attribute which any designer possesses — creative ability. The elusive nature of this characteristic is evidenced by the variety of terms we resort to in distinguishing its operation. Words such as invention, ingeniousness, resourcefulness, originality, intuition and inspiration are all used to convey the thought that certain new ideas or solutions to problems come to individuals in a kind of revelation which borders on the supernatural. This is borne out by the fact that the mental flashes which give birth to new ideas may occur at times when the individual is not consciously occupied with the problem to which the revelation provides an answer. I have said that this faculty is the most important single attribute which the designer possesses. I say that because everything that is new, everything which represents a step beyond what is already known, involves some element of invention in bringing it about. Without it, mankind would be in a state of stagnation, unable to do more than simply to continue an unvarying routine of existence to the end of time.

Having thus defined creative ability, we are now compelled to face the fact that the process of mental creation cannot be substantially accelerated in any individual by any educational program yet devised by man. Each of us appear to have been endowed at birth with a particular quota of originality and our individual fates seem to be decided by how well we are able to make use of this one natural resource. Fortunately, we don't have to be so overburdened with this faculty as to be called geniuses in order to design farm implements, but some creative ability is an absolute necessity.

The nearest approach to creative ability which can be brought about by an educational process is the habit of thinking analytically. This is best described as a systematic separation of a given task into a series of component problems which may then be attacked one at a time. Analysis, to quote directly from Webster, "clarifies rather than increases knowledge". But the process of clarification frequently distinguishes the correct approach to a problem which would not otherwise have been apparent. Analytical thinking also serves as a means for detecting and rejecting spurious hypotheses concerning machine behavior. Although this is a negative function, it is a particularly necessary one for the proper evaluation of ideas which come into being by the revelation method. Inventive geniuses are frequently given to laboring for long periods of time over notions which less gifted, but more analytical persons would soon dismiss as being fundamentally unsound. Thus, in the farm implement designer, analytical thinking frequently saves time and energy spent in fruitless investigations of a trial-and-error nature where there is no real foundation for supposing that a solution exists.

This completes the description of the attributes which define the ideal farm implement designer. Our training goal, then, is to develop a person having a knowledge of mechanical-engineering techniques, a knowledge of structural and agricultural materials, a knowledge of manufacturing processes, some creative ability and a faculty for thinking analytically.

Candidates for the Goal of Farm Implement Designer. The candidates for this goal fall into three well-defined groups. They are either graduates of engineering colleges, graduates of formal machinist apprentice training courses, or self-taught individuals who have demonstrated their originality in some concrete manner without the benefit of any formal technical education. No one of these groups comes equipped with all of the attributes which I have just outlined, nor is there any uniformity in the kind of deficiencies which they exhibit. On this account, then, we shall have to postpone any discussion of the training procedure until we have examined these deficiencies in some detail.

Taking the groups one by one and in reverse order, we examine first the self-taught individual who has no formal technical education. In times past, when a formal education was more difficult to acquire, this type of person appeared quite frequently as a candidate for the designer's rating. My own father is a good example. He came to the International Harvester Company with a farm background, a one-room country grade school education and a working automatic grain shocker which he had developed himself by the time he was 25 years old. Some self-taught individuals came into the designership by demonstrating originality as mechanics in the shop or on the setup floor where they learned the technical side of the business by observing and living in the development process. But today, when a college education lies within the reach of a much larger share of the population, young men who exhibit unusual talents are almost certain to get the assistance of a scholarship or part-time job if they do not possess sufficient means within their own families. The self-taught individual is a fast-declining and therefore less reliable source of designer material. We salute the accomplishments

A spectacular use of large tractors pulling heavy battleship anchor chains is being made by Texas cattlemen to restore pasture lands which have become infested with noxious weed trees and brush, especially mesquite. This picture shows the operation on a 75,000-acre ranch near Sinton with an International 148-hp TD-24 diesel track-type tractor hitched to each end of a 262-ft chain weighing 25,000 lb. Each link of this chain is 13 in long, is made of stock 3¼ in in diameter, and weighs 99¾ lb. Pushing and bulldozing their way through heavy thickets of trees and brush, these tractors provide a steady pull on each end of the chain that causes brush and trees up to 22 in in diameter to be uprooted. Like a man-made tornado, these tractors, with the heavy chain in a big loop behind them, tear up the noxious growth in wide swaths at the rate of 40 acres an hour, or 400 acres in a 10-hr day. Inside the looped chain, amid the crackling of falling trees, race frantic rabbits, skunks, rattlesnakes, etc.

of previous generations that included Cyrus McCormick and Thomas Edison, but the chances of such men appearing today at anything less than the apprentice level become too remote to merit serious consideration in a training program.

Graduate apprentices, especially those who have served their time in the farm tractor or implement industry, have good possibilities for becoming farm implement designers. Their training includes experience with both the practical and theoretical aspects of simple engineering techniques, a good appreciation of iron and steel as structural materials, an excellent appreciation of the major manufacturing processes and considerable encouragement in orderly thinking. If the apprentice has any creative ability, he may be able to demonstrate it on some independently assigned task before the termination of his training period. His deficiencies lie mainly in the realm of the more advanced engineering techniques and in the lack of any knowledge of agricultural materials and practices.

ENGINEERING QUALIFICATIONS FOR DESIGNERS

Graduates of engineering colleges appear to be better fitted than apprentices to the task of becoming farm implement designers, but they too exhibit certain deficiencies. Here it becomes necessary to distinguish between mechanical and agricultural engineers. Generally speaking, mechanical engineers receive a fairly complete education in mechanical-engineering techniques. They also receive a fair picture of manufacturing methods so that the only deficiency is in the realm of agricultural materials and methods. However, a mechanical engineer who was reared on a farm avoids this deficiency by virtue of his boyhood experience and observation. Given, in addition, some creative ability and a capacity for thinking analytically, the mechanical engineer with a farm background meets all the requirements as originally laid down. Agricultural engineers, on the other hand, are not primarily concerned with mechanical-engineering techniques in the training which they receive, nor do they receive any formal education in manufacturing methods. This is not surprising since agricultural engineering is, after all, primarily concerned with the physical aspects of scientific crop and livestock production and only incidentally with the design and manufacture of the tools which are used. Agricultural engineers then, although they have a comprehensive knowledge of agriculture, are usually deficient in advanced engineering techniques and manufacturing methods. In recent times, however, a few schools have made determined and successful efforts to raise the standards of the mechanical-engineering side of the agricultural engineering curriculum. Graduates of these institutions have a correspondingly better chance of qualifying in all the departments of the farm implement designer's activity.

The irony of the situation lies in the fact that mechanical engineers, while generally well suited to the needs of the farm implement industry, are totally unaware of it in so far as their curriculum content is concerned. No mechanical engineering course deals specifically with the design of farm machinery. On the other hand, agricultural engineers are acutely conscious of the farm implement industry because they work with its product in practically every branch of agricultural activity. But, in most of the courses dealing with farm machinery, the student is schooled in intelligent machine operation rather than in the fundamentals of design. I do not mean to infer that such courses should be revised because, in the interest of American agriculture they are a very necessary part of the curriculum. But I do want to point out that, for the purpose of training a farm implement designer, advanced courses should be provided of a more specific nature. I have been quite pleased to notice a few pioneering efforts in this direction. There may be others, but Agricultural Engineering 436 at Iowa State College and Agricultural Engineering 171 at the University of Minnesota are examples of such courses which have come to my attention in recent times.

After looking over the various educational programs available today, we are forced to the conclusion that no one program provides all of the material necessary to the making of a farm implement designer. Apprentices, graduate mechanical engineers and graduate agricultural engineers all possess some part of the requirements, but in every case the missing remainder must be supplied by the employers of these men after they have gone to work in the industry.

Bridging the Gap Between Training and the Goal of a Designer. Bridging the gap, as I see it, involves two things. First, the deficiencies of the individual candidate must be removed by some educational process, whether formal or informal, and, second, the individual must acquire sufficient experience to temper his judgment and thus bring about the perspective view which is characteristic of maturity in any field.

Historically, the training process in farm implement engineering has been exceedingly informal. There are no classrooms, no textbooks, no formal examinations and no awarding of diplomas or degrees at the end of the year. Instead, the potential designer is simply put to work at whatever level his present talent may decree, and he is left to work out his own salvation as best he can. He learns by doing and from the men around him. The variety of his assignments is determined by the amount of interest the chief engineer may happen to have in developing new employees, and the whole thing proceeds at a rate which is determined solely by the individual's initiative and desire to learn. This seemingly haphazard method of training has several strong points which we cannot lose sight of in proposing a switch to some formal training program.

In the first place, the informal method of training takes candidates with a wide variety of previous training and experience and handles them with equal facility. Self-made inventors, apprentices and college graduates all go into the same mill and continue to learn at whatever level of engineering operation they are able to comprehend.

Secondly, the duration of the training program is not rigidly prescribed and does, in fact, continue as long as the trainee is willing and able to profit from the work experience provided him. We are not obliged to call a man a farm implement designer simply because he has spent a certain length of time taking part in development activity of a particular nature. Nor are we obliged to wait for a predetermined length of time if his performance indicates outstanding ability in comparison with his colleagues.

And, thirdly, the informal method requires no great effort to administer from the employer's point of view. A normal part of the chief engineer's job is the evaluation of all of his employees, including the younger members of the department, and where he takes an active interest in their development, the needs of the younger men do not long go unnoticed.

SOME WEAKNESSES IN TRAINING IMPLEMENT DESIGNERS

On the opposite side of the discussion, there are two serious weaknesses in the informal method which are just now being faced by the farm implement industry. Taken together, these two weaknesses constitute a serious challenge to the wisdom of relying exclusively on the informal method of preparing new men for the post of farm implement designer.

The first weakness is brought about by the increase in size of individual plants and engineering departments. In small plants, the young man stands a good chance of getting acquainted with every activity of his own department and the shop as well. I feel particularly fortunate in having begun my own service at the Auburn Works of the Harvester Company which employed only 400 persons at the time. But one year later, I had not only handled my regular assignments as an engineering novice, such as making detail drawings, small layouts and simple calculations, but had also made thousands of blueprints, filed hundreds of tracings, written specification cards, taken photographs for owners' manuals, collected data for repair catalogs, made experimental parts in the shop, assembled experimental machines and operated them in the field, loaded freight cars, painted samples, counted and costed inventory, had gotten my nose into every department in the plant and knew practically every operating foreman by name. Such were the benefits of the informal method. But in the large plant and large engineering department, such things don't take care of themselves. The chief engineer has more

problems and is less inclined to put forth the additional effort required to circulate new men over all these activities. I am of the opinion that my experience could not be duplicated at the McCormick Works today without the help of some benefactor to whom my training had been entrusted as a specific duty. Even aggressive persons can get cooped up in a large department and fail to get the perspective of a large plant operation in their early years.

By the same token, when the candidate does get an opportunity to work in another department, it is again a big one and his experience suffers accordingly. The foreman, who has no interest in the candidate and ten other jobs to do, frequently assigns the new man to some spot where he will be "out of the way" rather than to give him representative work experience. It is much easier to set a man to shoveling sand in the foundry than it is to interrupt a molder who is completely occupied with his job or to get in front of a ladle of hot iron or explain the fine points of properly gating a new pattern. What this whole point adds up to is the need for a director of engineering training who is specifically charged with the responsibility of giving the candidates wide experience and looking out for their interests when conflicting factors enter into the picture.

The second weakness of the informal method is derived from a larger situation involving more than training methods alone. It has to do with the current level of design technology in the farm implement industry and its impact on the buying public. Farm implement construction has been a frequent target for criticism in reputable magazines of national and international circulation. Some of the statements made are too pertinent to be ignored. As a good example, I direct your attention to an article which appeared in *Fortune* magazine, October, 1948, issue, entitled "Farm Horsepower". A sample quotation reads thus:

> "(the farm-equipment industry) has not been attractive to many engineers, since so many other industrial fields offered far greater promise. In the past, much of the engineering was done by 'graduate blacksmiths.' Although in recent years many of the large companies have taken on more young engineering talent, no company could be said to be overburdened with it even now."

After evaluating the present farm implement industry in terms of its contribution to American agriculture, one can hardly describe the work of these "graduate blacksmiths" as deplorable. On the contrary, the strides made in this field during the past century represent a flowering of pragmatic ingenuity which is absolutely unparalleled in the entire agricultural history of mankind. The real question which *Fortune* raises is whether we can continue with the same methods which have been so successfully employed in the past.

ROLE OF CREATIVE WORKERS IN IMPLEMENT DESIGN

Creative workers in implement design appear to have been guided mainly by their own personal experience supplemented by the knowledge of fellow workers or supervisors with whom they had established contacts. At best, the art appears to be maintained on a word-of-mouth basis and advances in the field are documented only by the marketed designs of the various manufacturers. This system is now being challenged by two circumstances which indicate that farm implement design methods will be obliged to evolve upward to a more scientific level: (1) Further advances in the art are becoming increasingly difficult under the personal experience system because of the increasing length of time required to come abreast of what is already known in the field. Continued pursuit of the trial-and-error method now runs a greater risk of duplicating the discarded effort of previous workers. (2) Other new products and conveniences made possible through application of the academic sciences of physics, chemistry, and electronics have made the buying public more conscious of the design methods used and the results obtained thereby. Similar methods are being expected of the farm implement industry.

The significant aspect of the situation is this: if we are not only to train young men to become farm implement designers, but also to raise the level of design technology at the same time, then we must take unusual precautions to see that new men are indoctrinated at the highest possible level. They must be put in contact with the most advanced practitioners of farm implement design and not allowed to deteriorate or lose sight of their ideals when they have finished the training period whether formal or otherwise. On this score, the responsibility of the director of engineering training becomes doubly great — he must cope with the evils of bigness and with a changing level of technology at the same time.

In the final analysis, it means that those who are best able to bridge the gap must have strong minds. Whether they be self-made inventors, apprentices, mechanical or agricultural engineers, they must be people with ideals and principles as well as ability — people who are conscious of the trends in the industry — analytical thinkers who are able to sort out the good from the bad on a rational basis and pursue the object of any investigation with unswerving determination.

Proposals for Improving the Training Technique. Before embarking upon any proposals for improving our training technique, I shall pause to summarize the factors which need to be taken into account, including certain additional factors which have not been introduced in the preceding discussion. Some of these factors apply mainly to the industry, some apply mainly to the educational institutions, and some apply to an intermediary institution which has not yet been identified. I feel that the American Society of Agricultural Engineers, since it serves both the educational institutions and the farm implement industry, is the logical institution to play an intermediary role. My suggestions then, as to the part it can play in this matter, are directed specifically to the Society for its consideration.

Getting back to the factors which need to be taken into account, the position of the farm implement industry appears to be determined by the following considerations:

1 The level of design technology is slowly but steadily rising in the direction of scientific improvement. Because of this change which is now at work and which is moving at different rates in different firms, the industry is unable to be articulate in defining either the kind of training which a farm implement designer should receive or the educational level at which he is most likely to be found.

2 The number of new men who are taken into a given firm in one year is so small and are taken into the organization at such widely separated points that a formal training program for farm implement designers seems not to be worth the undivided effort of one man acting as their educational director.

The position of the educational institutions appears to be governed by the following considerations:

1 Schools and colleges have difficulty in arranging the proper curriculum for a farm implement designer, because they have no clear statement from the industry as to the type or level of training which is desired. The technical literature and textbook material from which college courses are usually taught simply have not yet come into existence in the field of farm implement design.

2 The number of engineering graduates who are employed as potential farm implement designers each year is too small to warrant the establishment of a special curriculum in more than a few schools.

In view of the circumstances just described, it should be plain that the primary function of the intermediary institution is to get the needs of the industry crystallized and delivered to the schools and colleges. These institutions are eager to do what they can to fit their graduates to the needs of American agriculture. I therefore propose two activities which the Society could sponsor as a means of bridging the gap and shortening the training program. The first activity is a relatively simple one and could be undertaken immediately. The second is a task of greater dimensions and should not be attempted without careful consideration.

The simple activity is a kind of thing which is now being employed successfully by the American Society of Mechanical Engineers. They are, of course, faced with a similar problem in preparing engineering graduates *(Continued on page 26)*

Fundamentals of Drying Baled Hay

By Roy B. Davis, Jr. and Vernon H. Baker
JUNIOR MEMBERS A.S.A.E.

THE shortage of labor during the war and postwar years encouraged many farmers to substitute machinery for hand labor. This fact gave impetus to the use of hay balers in handling hay. More and more hay producers in Virginia and the Southeast began using balers to reduce the amount of labor required in their harvesting operations. The success experienced by many in drying long and chopped hay raised questions on whether or not they would be able to get comparable results in drying baled hay. A few farmers were soon drying baled hay with reasonable success on systems designed for long hay and chopped hay. The drying system has remained the same, except for minor modifications which experience has shown desirable. Twenty-three of the 90 driers installed in Virginia in 1949 were installed for drying baled hay.

In initiating research dealing with the drying of baled hay, information was found which was primarily of value in making modifications on the systems used for drying long hay. Much of the work (1,2,5,6)*, however, had been for drying systems for air velocities of around 100 fpm. Since most of the drying systems installed in Virginia had been designed for a much lower air velocity, (15 fpm), the investigators of the Virginia Agricultural Experiment Station and the Division of Farm Electrification (BPISAE), U. S. Department of Agriculture, were interested in developing a drying system for baled hay using the lower air velocities and in determining whether the present system designed for long and chopped hay could be modified for drying baled hay satisfactorily. They were also interested in studying the fundamentals of drying baled hay in order that prediction charts, similar to those formulated for long and chopped hay, might be developed for drying bales. These prediction charts would be used to determine the proper operating conditions for baled hay driers when conditions under which they were to be operated were known.

Experience in drying long and chopped hay had shown that for best results it is desirable to supply the energy to evaporate moisture uniformly from the entire drying area. This meant that uniform air distribution was required since air was the medium by which this energy was carried to the hay. To obtain uniform air distribution, uniform distribution of the hay over the drying system was important. This meant, therefore, that the hay mass over the drying system should be so packed that its density was relatively uniform. The problem of obtaining satisfactory air distribution while forcing air through rather dense bales of hay as well as through the much less dense spaces between the bales apparently needed study. The bales themselves would probably be of varying densities as shown by Weaver (1). The greatest variation in density, however, would be between the density of the bale and the density of the space between the bales. Weaver indicated that, with an average velocity of 100 fpm or more, space left between the bales did not retard drying. Since the velocities used by Weaver greatly exceeded those commonly used in Virginia driers, it was decided to study the effect of lower velocities of 15 to 25 fpm in drying baled hay. The lower air velocities were considered desirable since the power requirement for forcing air through hay increases very rapidly with increased air flow. Hendrix (2) showed this relationship to be exponential of the 2.5 power for long hay; therefore, to keep the power requirements for drying within the range normally supplied by rural electrical distribution lines, the lower velocities were thought desirable.

Based on the foregoing consideration, one of the first questions appeared to be: Does method of stacking affect the rate and uniformity of drying at the lower air velocities, and, if so, what is the most desirable method under these conditions?

As far as could be determined from a preliminary study, some of the factors affecting baled hay drying in addition to the method of stacking would be: (a) initial moisture content of the bale, (b) velocity of the air passing through the stack, (c) condition of the air, (d) density of the bale, (e) kind of hay and maturity, and (f) movement of moisture in the bale.

Equipment and Procedure. In an effort to evaluate the factors enumerated above, special drying equipment was designed and built in which these factors could be studied. This drying equipment (Fig. 1) consisted of two bins, each placed over a plenum chamber to which air was supplied by a blower. An additional plenum chamber was placed over each bin so that the air might be collected after it has passed through the bales and its condition determined. The bins were constructed so that bales could be placed in them either one layer or two layers deep and either on edge or flat. A bale was "on edge" when its shortest side was placed so that the air from the plenum chamber entered the cut edge. The bale was "flat" when its longest side was placed horizontal when the direction of air movement was vertical. These bins, with the plenum chambers, were suspended from calibrated springs, the lengths of which were continually recorded. The decrease in the length of the springs showed the loss in weight in the drying process. The velocity of the air used for drying was controlled by varying the speed of the blower. The air temperature was regulated by passing it through thermostatically controlled steam radiators.

This paper was prepared expressly for AGRICULTURAL ENGINEERING, and has been approved by the Director of the Virginia Agricultural Experiment Station as Paper No. S107-8 on The Forage Drying Research Project in cooperation with the U.S. Department of Agriculture.

The authors: ROY B. DAVIS, JR., and VERNON H. BAKER are, respectively, formerly associate agricultural engineer (BPISAE), USDA, and associate agricultural engineer, Virginia Agricultural Experiment Station, Blackburg, Va.

AUTHORS' NOTE: The authors wish to express their appreciation for the assistance of R. C. Carter and Dr. C. M. Kincaid of the animal husbandry department of the Virginia Station for their help in obtaining hay for the research work reported in this paper. Jerry Whitehurst and A. J. Lambert, seniors in agricultural engineering, assisted with the experiment.

*Numbers in parentheses refer to the appended references.

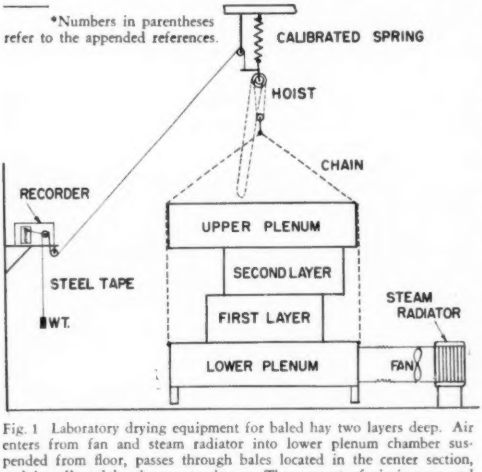

Fig. 1 Laboratory drying equipment for baled hay two layers deep. Air enters from fan and steam radiator into lower plenum chamber suspended from floor, passes through bales located in the center section, and is collected by the upper plenum. The amount of air is measured by the orifice plate located in the center of the top plenum chamber. The entire unit is suspended on the chain from a calibrated spring. The recorder measures the length of the spring as drying progresses

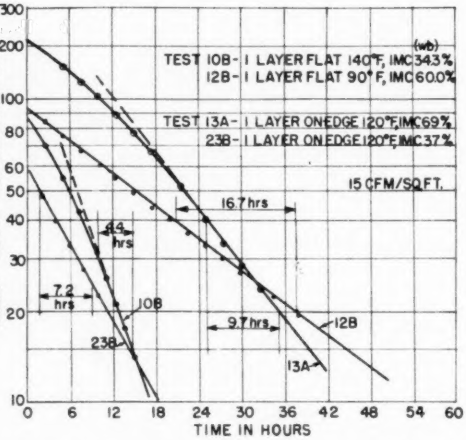

Fig. 2 Four drying curves plotted on semilogarithmic graph paper illustrating the method used to determine the drying factor F

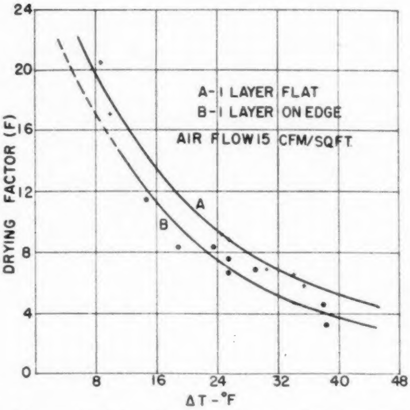

Fig. 3 Relationship of the drying factor F to air condition expressed as the difference between the wet- and dry-bulb temperatures entering the hay when the bales are dried flat and on edge

The hay for the drying tests was cut as near the recommended stage of maturity as possible. The hay was usually cut in the morning and, when possible, raked the same afternoon and baled the next day with a conventional baler. After baling, the bales were placed in a jig and shortened to a length of 30 in without changing the density of the bale. These bales were then placed in the drier, with 3 bales in each layer. The size of the container for each layer was such that, when the 3 bales were placed in it, each would occupy a space equal to that which it had occupied in the baler. In other words, the container for 3 bales on edge was 42 in long, 30 inch wide, and 18 in deep, thereby making it possible to place therein three bales 14x18x30 in in size. To do this, it was necessary to use clamps to close the container. This was done to minimize the space between the bales and to make it as uniform as possible. The two units were loaded at the same time and operated under the same conditions, except that one bin was operated only 50 to 90 per cent as long as the other, depending on the drying rate, operating conditions, and convenience of operation. The purpose of this variation in drying time was to enable the operators to remove the hay before it was completely dry and check the uniformity of drying inside the bales. As the bales were removed, the center bale in each layer was broken open and the center section placed in a sampling jig. Samples of hay were cut from the bale at uniformly spaced points and the moisture content of these samples determined by oven-drying. Since this was done for both the drying bins, two points in the drying process were obtained for uniformity of drying studies. The temperature of the air passing each point at which a sample was taken was recorded during the drying process. This was done by placing a thermocouple at each of these points before the drying started and recording the temperature at each point with a recording potentiometer.

A total of 28 drying tests were made in each of the two drying bins. This gave a duplicate on each test except with regard to drying time. Clover and timothy hay were dried in five of the tests, orchard grass in two, and alfalfa in the remainder. The data in this paper are for alfalfa hay only. In twelve of the tests, the bales were dried flat, one-layer deep. In these tests, air velocities of 10, 15, and 20 fpm were used with the temperature of the air being controlled at approximately 90, 100, 115, and 130F. Eleven of the tests were dried with the bales one layer deep on edge. Air velocities of 10, 15, 20, and 25 fpm were used with the temperature ranging the same as above. Five tests were conducted with the bales, two-layers deep, on edge.

Drying Rates. In analyzing the observations made on this group of tests for alfalfa hay, an effort was made to determine whether or not the observed drying rates fitted the prediction curves for long and chopped hay recently presented in a paper by Davis, Barlow and Brown (4). The amount of hay actually dried was compared with that which would have been dried had the prediction curves been applicable. Since this hay was dried to a depth of only one layer of bales in most tests, the number of depth units involved was quite low. The results of this comparison showed that in this low range the prediction curves applied quite well to the bales dried on edge. The bales which were dried flat dried much slower than the prediction data indicated they should have, in fact only three-quarters as fast. It must be realized, however, that these tests were for very shallow depths of hay and no attempt should be made to predict drying behaviors for greater depths of baled hay by extrapolating from these data. It is believed that further tests should be made with greater depths. There were no great differences between the drying rates of the other hay tested and alfalfa when the hay was cut at the recommended stage of maturity and had about the same initial moisture content and density.

A study of the weight records during the drying period shows that in some cases water was removed at a fairly constant rate during the early part of the drying period, but this rate became less and less during the later stages of drying. In other cases, the drying rate showed this falling-rate characteristic from the very beginning of the tests. When plotted on semilogarithmic graph paper with drying time as the arithmetic abscissa and the difference between the weight of the hay in the drying bin and its equilibrium weight as the logarithmic ordinate (Fig. 2), the curve was in some cases a straight line and in the remainder became straight after some of the drying time had elapsed. Further study of these data showed that, when the initial moisture content of the bales

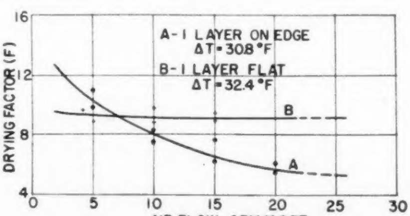

Fig. 4 Effect of the amount of air on the drying factor F when bales are dried flat and on edge

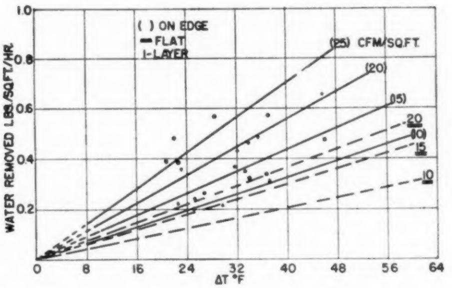

Fig. 5 Effect of air condition expressed as the difference between the wet- and dry-bulb temperature of the entering air on the moisture removed in pounds per square foot of drier area per hour of drying time at varying amounts of air

in the tests was below 40 to 45 per cent (wet basis), the curve was a straight line from the beginning of drying. When the initial moisture content was above this level, the curve became straight after a portion of the drying time had elapsed. The number of hours elapsing before the curve became straight appears to depend on the amount of water to be removed. This would be affected by both the initial moisture content and depth of hay.

From these curves on semilogarithmic graph paper, a drying factor F was determined for each drying test. This drying factor was based on the straight line portion of the drying curve and is defined as the time in hours required for the weight of the bales to reach halfway to its equilibrium weight. For example, a bale of hay weighing 80 lb has an equilibrium weight, based on the operating conditions, of 64 lb and a drying factor F of 6 hr. This means that in the first 6 hr of drying, 8 lb of water would be removed; in the second 6 hr, 4 lb and so on until the equilibrium weight was virtually reached. These drying factors were found to vary with the condition of the air being used for drying and the amount of air being supplied. When F is plotted against ΔT, there is a definite decrease in F with an increase in ΔT. (ΔT is defined as the difference between the dry-bulb and wet-bulb temperature of the air used in drying.) The curves in Fig. 3 show this relationship for bales, one layer deep, flat and on edge. The curves show definite asymptotic characteristics towards both the X and Y axes. This characteristic should be expected and follows the findings of Brown (4) regarding the relationship of air condition to the drying rate for fully exposed hay. The principal thing to note in comparing these two curves is that, for a given condition and amount of drying air, the drying factor is less when the bales are dried on edge. Under the same conditions of temperature and humidity this drying factor appears to be affected by the amount of air used (Fig. 4). This effect is much more pronounced when the bales are being dried on edge. Thus it might be concluded that the value of this drying factor is established by both the condition and amount of drying air passing through the bale and the diffusion of moisture from the wetter portion of the bale to the drier portion. This diffusion is probably due to the difference in vapor pressure of the water in the hay and vapor pressure of the water vapor surrounding the hay. The relative magnitude of each of these effects could not be determined from the data available, but there is reason to believe that both do exist and play a part in drying baled hay.

A further study of the drying rates observed in these tests shows that the moisture removed, per square foot of drier area per hour of drying time, varied as would be expected with air condition, air volume, and initial moisture content of the hay. The drying time as used herein is the time in hours required to dry the hay to an average moisture content of 15 per cent (wet basis). The variations of moisture removed per square foot per hour as affected by ΔT are shown for bales flat and on edge in Fig. 5. The basic curve in each case was determined for an air flow of 15 cfm per sq ft. Although the curves for 10, 20, and 25 cfm per sq ft were based on fewer tests, they indicate that increased moisture removal may be expected when higher air velocities are used. It is observed that for a given air condition, the rate of moisture removal is greater from bales dried on edge. Higher initial moisture contents give a slightly higher rate of moisture removal. The increased rate of removal is approximately a linear relationship. Approximately the same rate of moisture removal per square foot of drier area per hour was observed in several tests in which the hay was dried two bales deep on edge. It would be expected that the greater depths would increase the rate of moisture removal slightly although this was not observed in the several cases in these tests. It is not considered that these data are sufficient to conclude that the same drying rate would hold for the different depths, since increased drying efficiency is usually obtained by increasing depth. For approximate calculations, however, the drying rate indicated in this figure should be acceptable.

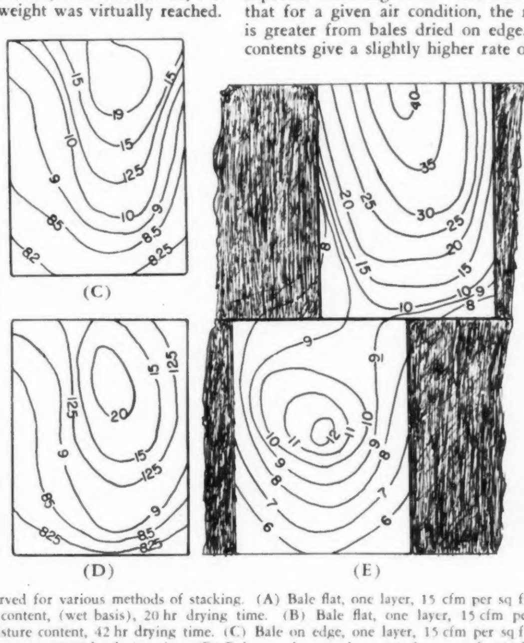
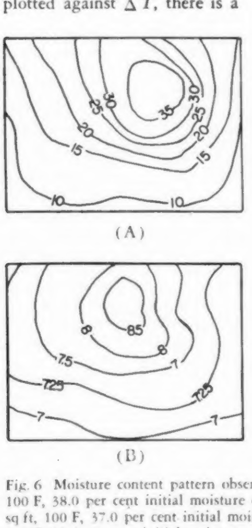

Fig. 6 Moisture content pattern observed for various methods of stacking. (A) Bale flat, one layer, 15 cfm per sq ft, 100 F, 38.0 per cent initial moisture content, (wet basis), 20 hr drying time. (B) Bale flat, one layer, 15 cfm per sq ft, 100 F, 37.0 per cent initial moisture content, 42 hr drying time. (C) Bale on edge, one layer, 15 cfm per sq ft, 100 F, 35.4 per cent initial moisture content, 17.75 hr drying time. (D) Bale on edge, one layer, 15 cfm per sq ft, 100 F, 35.4 per cent initial moisture content, 22.66 hr drying time. (E) Bale on edge, two layers, 15 cfm per sq ft, 100 F, 40 per cent initial moisture content, 39.5 hr drying time

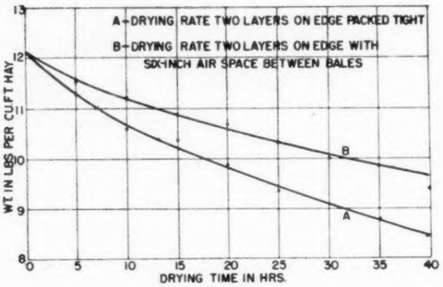

Fig. 7 Effect of air space between bales on drying rate, 15 cfm per sq ft, 100 F, 38.6 per cent initial moisture content

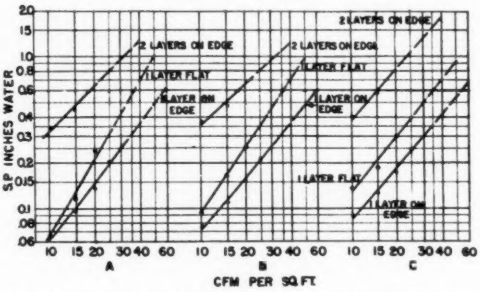

Fig. 8 Resistance of baled hay to air flow. (A) Density, 8 lb dry matter per cu ft. (B) Density, 10 lb dry matter per cu ft. (C) Density, 12 lb dry matter per cu ft

Uniformity of Drying. As was mentioned earlier in this paper, bales were removed from the drier, in most cases, before complete drying had taken place and the center portion of the center bale in each layer was sampled to determine the moisture variations in a plane parallel to the direction of air flow. The moisture content pattern observed for various methods of stacking is shown in Fig. 6 (A,B,C,D and E). Fig. 6 (A and B) show the moisture content pattern existing in the bale after 20 and 42 hr of drying when the entering air temperature was 100 F, and the air velocity was 15 fpm. The initial moisture content for the bale used in obtaining Fig. 6 (A) was 38 per cent and for the one used in obtaining Fig. 6 (B) 37 per cent. Both bales were dried flat. The lines on the chart connect points of equal moisture content as estimated from the moisture content determinations at 19 points within the bale. In general, Fig. 6 (A) shows that after 20 hr of drying the bale had dried completely along the bottom and both sides. The top center of the bale, however, was still at a very high moisture content approaching the initial moisture content. Thus, in this bale, the moisture content differential within the bale at this stage of the drying was rather large. It will be observed from Fig. 6 (B), which was sampled after 42 hr of drying, that the same general pattern of moisture content exists, but that the moisture content differential at this stage of drying is much less. In this case, the variation in moisture content within the bale was from 7 to 9½ per cent. Here again the top center of the bale had the highest moisture content.

The results obtained when drying bales on edge are shown in Fig. 6 (C and D). Fig. 6 (C) shows the results obtained from a bale, which had an initial moisture content of 35.4 per cent, after it had been dried for 17¾ hr with air at 100 F and 15 fpm. Fig. 6 (D) shows the results obtained from a bale which had an initial moisture content of 35.4 per cent after it had been dried for 22⅔ hr under the same conditions as specified for Fig. 6 (C). In general, the same type of pattern is observed in both instances and the moisture content differential is almost the same. In Fig. 6 (C) the differential was from 8.25 to 20 and in Fig. 6 (D) from 8.25 to 26. When Fig. 6 (C and D) are compared with Fig. 6 (A), it is observed that large differences exist between the highest moisture content observed in each bale. These bales, having approximately the same characteristics, were dried under the same conditions for approximately the same length of time. Although the bales that were dried on edge dried more rapidly near the cracks between the bales, the moisture content differentials obtained in these tests indicate that those dried on edge had dried more uniformly than those dried flat. This might have been due to several causes but was probably due to the passage of more air through the center of the bale when it is being dried on edge.

The moisture content pattern for bales dried on edge two layers deep is shown in Fig. 6 (E). This pattern is a continuation of the one shown in Fig. 6 (C and D), except that, when the bales were offset as shown here, there appeared to be a tendency for the air to move horizontally along the cracks separating the layers and thus dry the top of the bottom layers faster than was usual when they were not covered. The most rapid drying took place in that portion of the bale adjacent to the cracks separating the bales in the layer and the cracks between the layers. At the end of the test, the bottom bale was dry enough for safe storage while the bale in the second layer had a much higher moisture content, with the top center portion only beginning to dry.

The observations indicate that the uniformity of drying was affected by initial moisture content, amount of air, condition of the air, and method of stacking, as well as drying time. An attempt was made to determine the relative effect of these factors, but a satisfactory method of correlating them does not appear to be available. The observations show, however, that in a given drying time higher initial moisture contents increased the variation between the highest and lowest moisture content in a bale. Increasing the temperature of the air used in drying tended to increase the variation in moisture content while increasing the rate of air flow tended to decrease it. As drying time progresses the difference between the highest and lowest moisture content in the bale would increase until areas of most rapid drying approached the equilibrium moisture, and thereafter the moisture content throughout the bale tended to become more uniform. The time required for these changes to take place was influenced by the factors enumerated above.

Effect of Wide Spaces Between Bales. One test was run in which a 6-in air space was left between the bales in each of the two layers. The bales in the second layer, however, were placed so that they covered the open space in the bottom layer. The results of this test are shown in Fig. 7. The two curves show the weight of material in the drier as drying progresses. It will be noted that the air space left between the bales resulted in a decreased drying rate. This difference in drying may be explained by two factors causing moisture to leave the bales. Where an open space was left between bales, the moisture removal was almost entirely dependent on the rate at which it could move by diffusion from the area of high moisture content to the outside, because of the difference in vapor pressure of the moisture at these locations. Secondly, where the bales were packed tightly together, moisture was lost both by diffusion and by evaporation into air moving through the bale. These observations indicate therefore that it would be desirable to stack the bales in such a way that as much air as possible passes through them rather than merely passing along the side when low velocities are used.

Resistance of Baled Hay to Air Flow. The resistance offered by baled hay to the flow of air is a very difficult subject to discuss since so much depends upon the method of stacking and the amount of space between the bales. Hendrix (5) found that 4-in static pressure with an air velocity of 100 fpm were required to force air through a bale sealed in a duct with paraffin. Weaver (1) used less than 1.5 in static pressure to force this amount of air through 3 layers when the bales were placed flat, and Miller (6) reported that this air flow was ob-

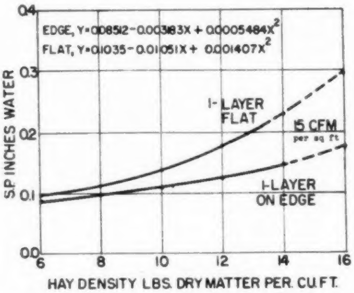

Fig. 9 Effect of density on resistance of baled hay to air flow

tained through 7 and 8 layers with approximately the same static pressure reported by Weaver. While density of the individual bales probably accounted for a part of this variation, it is believed that the greater part of the difference was caused by the method of stacking the bales. Hendrix also reported a relationship between static pressure and air flow over a considerable range of static pressure.

Observations were made on the static pressures required to force the various amounts of air used in the tests reported herein. Fig. 8 shows the results of these observations for several of the densities encountered. When the observations were plotted on logarithmic graph paper, the points tended to form a straight line. The static pressure required to force a given amount of air through baled hay one layer deep was much less than Hendrix reported. Since the only method used to prevent air passing between the bales was to force them tightly together, air did not pass uniformly through them, as had been shown in the preceding discussion of uniformity of drying.

STATIC PRESSURE-AIR FLOW RELATIONSHIPS

Fig. 8 shows the static pressure-air flow relationships for the two methods of stacking used in these tests. Bales one-layer deep on edge offered less resistance to a given air flow than did bales one-layer deep stacked flat. Another difference noted was that rate of increase of static pressure with an increase in air flow was greater for the flat bales. When plotted on logarithmic graph paper, the slope of the air flow-static pressure relationship for the flat bales approached that normally expected for air flow through ducts. This is probably due to the fact that a greater portion of the air was being forced through the space between the bales. This reasoning is confirmed by the results of the uniformity of drying studies mentioned earlier in this report. The exponent of the relationship for bales on edge was of the order of that reported for other types of hay dried in previous work (2,7). The mechanical structure of the bale as it appears to the air stream as it approaches the two sides in question may be the reason for the difference in the value of this exponent. This leads one to wonder whether bales from other types of balers would substantiate these observations. Since only one make of baler was used for baling hay in these studies, this question must remain for future study.

The static pressures encountered for bales dried two layers deep, on edge, are also shown in Fig. 8. These pressures were considerably higher than could be justified by a linear relationship between static pressure and layers for a given air flow and indicate that the method used for stacking in the laboratory was fairly effective in breaking the cracks between the bales.

The density of the bale had an effect on the resistance offered by the bale to the flow of air. The static pressures required for various densities are shown on the curves in Fig. 9. It is noted that for a given air flow the increase in static pressure as density increases is greater for the flat bales than for those on edge. A possible reason for this is that since air has more trouble entering the flat side of the bale, packing the bale tightly merely aggravates this situation.

In summarizing this phase of this study it should be mentioned that in field tests conducted here, static pressures of about ½ in have been encountered when an air flow of 30 cfm per sq ft was forced through 4 bales deep on edge. These observations were made on hay that had been stacked as tightly together as is practical in the field. Considering this and observations reported by Miller (6) and Weaver (1), it would appear that the actual static pressures required under field conditions would be slightly less than those normally required for long or chopped hay. Care used in stacking would have a great influence on the static pressures required. While further studies on this subject are certainly desirable it would appear that ¾-in static pressure should be sufficient to force 15 to 20 cfm per sq ft through bales stacked on edge to a depth of 6 to 8 bales.

SUMMARY AND CONCLUSIONS

The extent to which these studies might be carried to obtain even limited coverage of the several factors affecting the drying of baled hay, makes one hesitant to draw conclusions until further tests have been conducted. In summarizing, however, it is believed these data allow the following conclusions to be made:

1 Prediction data can be developed for drying baled hay which would facilitate the design of satisfactory drying systems.

2 For more rapid, more uniform drying, bales should be stacked on edge so that air enters the cut side of each bale. They should be packed together as tightly as possible when drying is done at low air velocities.

3 An increase in the drying rate is obtained when the wet-bulb depression of the air used for drying is increased. This drying rate is also increased with increases in the amount of air used.

4 The observed static pressures for mow drying of baled hay are slightly less than those normally encountered in drying long and chopped hay.

5 Based on limited field observations, it appears that ¾-in static pressure would be sufficient to force 15 to 20 cfm per sq ft through bales stacked on edge to a depth of 6 to 8 bales.

6 Bales that are tightly tied offer more resistance to the flow of air than do those loosely tied.

7 Based on field observations of baled hay drying installations in conjunction with the fundamental laboratory studies, it was found that proper management of the drying operation is the key to successful drying. This includes cutting the hay at the recommended stage of maturity, leaving it in the field until the moisture content is 35 to 40 per cent (wet basis), baling the bales as loosely as possible in lengths of 30 to 36 in for easy handling, and use of supplemental heat where the atmospheric conditions are not favorable for natural air drying.

8 The main recommendation for modification of the slatted-floor drying system, based on these studies, is to change the design so that the bales may be stacked in the mow with less difficulty. This difficulty is caused by the step-down of the slatted floor, the taper of the main duct, and its location in the center of the mow.

This work will be continued to extend the data presented herein for baled hay up to eight or more layers deep and to investigate the merits of drying other types of bales.

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Adjustment of Soil-Fumigant Injectors with Engine-Driven Pumps

By Rene Guillou
MEMBER A.S.A.E.

SOIL-FUMIGANT injectors mounted on small tractors commonly provide for metering the fumigant to the individual injecting tines through orifices, which may be changed in accord with the desired application rate. Fumigant is supplied to the orifices by an engine-driven pump and some type of pressure regulator. Adjustment of the pressure regulator provides a second means of controlling the application rate.

Choice of the proper pressure and orifice size to give a desired application rate is a simple engineering problem, but to an operator in the field the interrelations of time, distance, and speed; of tine spacing, number of tines, width of cut, and acres covered; of applications in pounds or gallons per tine, per hour, or per acre, can become thoroughly confusing. Only a few attempts to assist farmer-purchasers in the interpretation of manufacturers' instructions are needed to demonstrate an opportunity here for some clear and careful selection of essentials.

A simplified method of adjustment has been worked out in cooperation with Mr. S. Hashimoto of the Pacific Chemical and Fertilizer Co. of Honolulu and with several farmer-users of fumigant injectors. The key feature is a table of distances traveled for injection of a fixed volume of fumigant per tine. This method, which speaks for itself, is not used in other published directions so far as is known. The instructions which we are supplying to users in mimeograph form are as follows:

The user must have the width, in inches, between tines on his machine, the desired application in gallons per acre, a ½ pt (1 cup) liquid measure, as many small cans as there are tines on the machine, a watch with a second hand, and means of measuring distance on the ground (pacing is sufficiently accurate). Adjustment and checking are then accomplished in four steps.

1 From the accompanying table, find the feet traveled for injection of ½-pt per tine. Measure off and mark this distance in a convenient place.

Application,	Width between tines					
gal per acre	12 in	15 in	18 in	24 in	30 in	36 in
7	389 ft	312 ft	260 ft	195 ft	156 ft	130 ft
8	340	272	226	170	136	113
9	302	242	202	151	121	101
10	272	218	181	136	109	91
12	226	181	151	113	90	75
14	194	155	129	97	78	65
16	170	136	113	85	68	57
18	151	121	101	76	60	50
20	136	109	91	68	54	45
22	124	99	83	62	50	41
24	113	90	75	56	45	38
26	105	84	70	52	42	35
30	91	73	61	46	36	30
35	78	62	52	39	31	26
40	68	54	45	34	27	23
45	60	48	40	30	24	20

2 With the second hand of a watch, note the time for the tractor to travel this distance, in the gear and at the speed to be used when injecting.

3 With the outfit stationary, place a small can under each tine. Engage the pump and run the engine at the speed to be used when injecting and for the time noted in 2 above.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author: RENE GUILLOU, agricultural engineer, Hawaii Agricultural Experiment Station.

(EDITOR'S NOTE: The author states that, having recently been called on to assist several farmers in adjusting tractor-mounted, soil-fumigant injectors, and having experienced confusion in trying to apply manufacturers' instructions, he was led to prepare instructions of his own which are included in this article.)

4 Adjust the pressure or orifices until the resulting discharge from each tine is approximately ½-pt. In case of excessive difference between tines, look for clogged strainers or orifices, or for unequal sized orifices. The test should be made with the fumigant that is to be used in the field, as more pressure or a larger orifice is needed to secure the proper feed with a heavy fumigant than with a light solvent or with kerosene.

Training a Farm Implement Designer

(Continued from page 20)

for industrial employment—except that their problem is greatly aggravated by the diversity of the mechanical engineering field. However, they do get the industrial message carried back to the various schools and colleges by sending industrial speakers to the student chapters of the ASME. These men are practicing mechanical engineers and their services are securd through the firms by whom they are employed. I have served in this capacity, and I know that a message can be carried to both students and faculty which is unique and distinct from anything they have been taught in school. My topic has been "Opportunities in Machine Design as a Career", but it has to be kept pretty general because of the wideness of the machine-design field. However, and this should be a point of encouragement for this Society, if farm implement designers and engineers were engaged as speakers for meetings of student branches of the ASAE, they could be a good deal more specific in the discussion of the requirements and opportunities for employment in the farm implement industry. This activity is a simple one and fairly easy to achieve because it requires no previous understanding between the firms of the industry.

The second activity which I am proposing involves a greater effort but also offers the possibility of providing more tangible results for both the industry and the educational institutions. Again under the sponsorship of the ASAE, I propose that a statistical survey of the practicing engineers and farm implement designers be conducted in the industry with regard to the following items of information: age, formal education, agricultural experience before entering the industry, organizational status, kinds of farm machines with which each is associated and size of employer. These various factors should then be correlated to determine the predominant educational characteristics of the present staff and by analyzing various age groups, to determine what trends, if any, can be detected in the educational characteristics of practicing members of the industry. This work should be supervised by an experienced statistician to eliminate bias from the presentation and to avoid false correlations of the data when finally compiled.

In the face of some real evidence as to what is actually taking place, it should not be too difficult to get a group of representatives from the various firms to sit down together and outline the real needs of the industry. This would, for the first time, result in a concrete statement of some benefit to the schools and colleges. Given academic representation on such a council, there is no reason to doubt that the engineering graduate could then be tailored to the exact design of his future employer.

In closing this paper, I would like to say that it has not been my intention to offend any member of the groups involved in my discussion but rather, if possible, to clarify a situation which is known to exist and which stands in need of some constructive thought. The opinions expressed are very largely my own, and if I have been guilty of any inaccuracies of observation I would appreciate having them called to my attention. My remarks have been made with the full knowledge of my employer and I have the Company's permission to volunteer my own assistance in carrying out the recommendations which I have made to the Society.

Artificial Curing of Peanuts

By J. L. Butt and F. A. Kummer
ASSOCIATE MEMBER A.S.A.E. MEMBER A.S.A.E.

THE advent of mechanized methods of harvesting peanuts in the southern states has resulted in a demand for information regarding artificial curing of that product. Experimental peanut pickers and combines have harvested peanuts successfully at all stages of curing from immediately after digging (35 to 60 per cent moisture) to field dried peanuts (6 to 8 per cent moisture). Although there is considerable need for improving the performance of these harvesters, it appears that the major difficulties are being overcome and that with additional modifications mobile peanut harvesters will come into general use.

Mobile peanut harvesters require windrowed or bunched peanuts to provide even feeding into the machine. The stacking operation and subsequent hauling to a stationary picker, which require considerable labor, are eliminated(8). But where peanuts are left in a windrow or in small bunches they are much more exposed to prevailing weather conditions than if they are properly formed into stacks. Thus, the advanced harvesting techniques have brought about a weather risk not heretofore encountered. In order to offset this risk, methods of artificially curing peanuts were investigated by the agricultural engineering department in cooperation with the botany and plant pathology department and the Wiregrass Substation of the Alabama Agricultural Experiment Station.

No increased yields of peanuts resulting from early harvesting and consequent reduction of shattering, such as occur in grain crops, have been reported; nor has conclusive evidence been found to suggest that artificial curing improves the quality over field-cured peanuts. Until such evidence is uncovered, the proper place for artificial curing is as insurance in the event of unfavorable weather rather than as a routine process included in the farm-to-market procedure.

Field Curing. Curing peanuts in the stack usually requires from 4 to 8 weeks depending upon the weather conditions. Extreme seasons have occurred that delayed the picking operation until January. Peanuts cured in windrows will usually dry to the generally accepted safe storage moisture content of 9 per cent in from one to two weeks of favorable weather. During the curing process, moisture is removed from the shells very rapidly during the first few hours of drying before a detectable reduction is found in the nuts. Fig. 1 is a typical curve showing the drying rate of shells and nuts during a favorable curing period. It has been shown that fluctuations in the moisture content of shells and nuts during curing are much more pronounced in the shells than in the nuts(1). It has also been reported that the hygroscopic equilibrium moisture content of peanut shells is higher than that of peanut kernels(6). This provides an explanation for the flat drying-rate curve for shells and the more rapid reduction in the moisture content of the nuts during the latter part of the drying period as shown in Fig. 1. At a constant relative humidity of 64.4 per cent, peanut kernels will have a moisture content of 7.04 per cent and peanut shells will contain 12.36 per cent moisture(6). This characteristic also explains why a shelled sample of peanuts usually indicates a lower moisture content on commercial moisture testers than an unshelled sample from the same lot.

Effect of Temperature on Rate of Drying. Before extensive efforts were expended in artificial curing tests, the effect of various drying air temperatures was investigated. Temperatures at 15 deg intervals from 100 to 205 F were used. Fig. 2 shows the time required to dry fully exposed peanuts from the initial moisture content shown to 7 per cent at any temperature within this range. Although the higher temperatures resulted in much more rapid drying, several factors prompted the selection of 115 F as the temperature to use in subsequent tests. In the first place, the layers of peanuts nearest the air chamber in a batch-type drier would become considerably overdried by the time the upper layers were dry enough to keep. Where the peanuts are to be used for food purposes, this is a disadvantage because during the shelling operation the nuts tend to split open and the protective skin flakes off, leaving the edible meats exposed to dirt and diseases. This disadvantage has been discussed by others(1, 9). In addition, there were indications that some of the nuts dried at 130 F did not maintain the high quality desired for edible peanuts. The effect of the high temperatures on total oil content and other quality factors is being investigated by plant physiologists of the Alabama Agricultural Experiment Station.

The rapid rate of drying of the shells during the early stages of curing was more apparent during artificial than natural drying. Fig. 3 is a typical drying-rate curve for shells and nuts dried at 115 F. The higher hygroscopic equilibrium moisture content of the shells probably caused the convergence of the two curves at the final testing.

Studies of Air Flow. In order to study the effect of air flow on the drying rate, two batches of peanuts from the same

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Biloxi, Miss., February 1950.

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*Numbers in parentheses refer to the appended references.

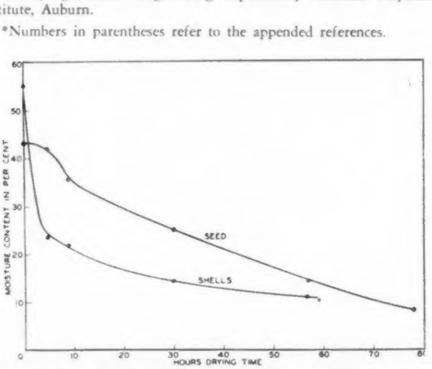

Fig. 1 Typical drying curve of peanut nuts and shells during favorable curing weather

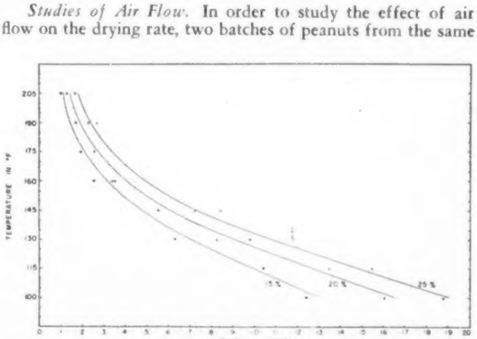

Fig. 2 The time required for fully exposed peanuts to dry from the initial moisture content shown to 7 per cent at the temperature indicated

lot were subjected to different rates of air flow. The unshelled peanuts contained 52 per cent moisture at the beginning of the test and the two rates of air flow tested were 13.25 cfm per sq ft and 23.8 cfm per sq ft. The nuts were placed to a depth of 18 in, and the amount of water removed

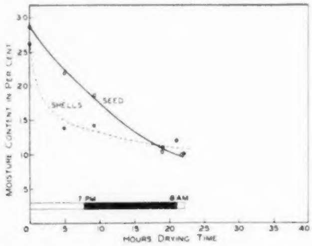

Fig. 3 Typical drying-rate curve for peanut shells and nuts dried at 115 F

from each 3-in depth layer was computed. These values, covering a total drying time of 12 hr, are shown in Fig. 4 and 5. (Twelve hours was selected as the maximum time that peanuts could be exposed to the warm, moist drying air moving through the upper layers of nuts without danger of damage to the nuts. This was purely an assumption agreed upon by the investigators involved, but which may be altered

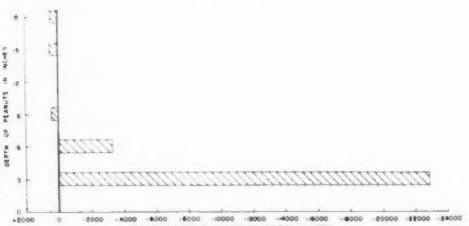

Fig. 4 Effect of air flow on drying rate of unshelled peanuts. Moisture removed from each 3-in layer of peanuts subjected to an air flow of 13.25 cfm per sq ft

as additional information is gained. Presumably, if the drying process has begun in all layers of peanuts within 12 hr and continues at that rate, no damage to the commodity will occur.)

At the lower rate of air flow the major part of the moisture was removed from the lower 3-in layer and none from the top 12 in. The zone of drying was too narrow to produce drying in all layers within 12 hr. This was not the case where the higher rate of flow was used. Drying had begun in all layers of peanuts although there was progressively less moisture removed from the 3-in layers toward the top. Hukill(4) states that the factors of depth of grain and rate of air flow in cubic feet per minute per square foot of floor area may be combined into a single factor of pounds of air per minute per unit weight of dry grain and handled independently of grain depth or air velocity. In converting the value of 23.8 cfm per sq ft into the single term, the quantity of air required to produce drying in all layers was found to be 0.0609 lb of air per minute per pound of dry peanuts or 121.8 lb of air per minute per ton of dry peanuts. Under the conditions of the test, this would amount to 1,705 cfm per ton of dry peanuts. At first this appears to be a considerable quantity of air to dry only one ton of peanuts, but upon noting that the ton of dry peanuts actually weighs over two tons before drying, the difference representing the amount of water to be removed, the high air flow appears quite reasonable. After the first 12 hr of drying time, approximately one third of the water is removed. In removing the remaining water to the safe storage moisture content, considerably more time is required. As the top of the drying zone moves above the top layer of peanuts, the air is no longer saturated to the equilibrium moisture content, and a portion of the available heat in the drying air is lost. Also, proportionately less of the total heat is available for drying, since the peanuts are at progressively lower moisture contents(4).

Analysis of the Drying Process. Hukill's formula for analyzing a drying process has been used to predict unknown values pertaining to the artificial curing of grain sorghum and ear corn(5). Davis and Barlow(2) have shown that the formula is adaptable also to hay crops. In order to apply this method of solution to peanut drying, certain basic information was determined. This information was used to compute values by Hukill's formula and checked by measuring the data during an experiment.

A series of tests was conducted to determine the time unit for the temperature and humidity conditions of the test. A time unit has been defined as the time in hours required for fully exposed hay to dry halfway to its equilibrium(2). The time unit selected for peanuts was the average of five values and amounted to 5.8 hr. The moisture content ratio (mcr) was determined by taking the moisture content (dry basis)

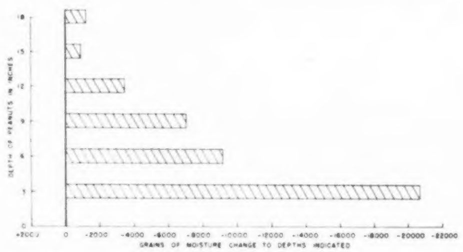

Fig. 5 Moisture removed from each 3-in layer of peanuts dried with 23.8 cfm of air per square foot

of a sample from the top layers of peanuts at the end of the test and, along with the initial and equilibrium moisture contents, substituting in the equation

$$MCR = \frac{MC\ \ (\text{db})\ \ \text{at time } x - \text{equilibrium } MC\ \ (\text{db})}{\text{Initial } MC\ \ (\text{db}) - \text{equilibrium } MC\ \ (\text{db})}$$

By substituting the values in the equation, the moisture content ratio was determined:

$$MCR = \frac{12.25 - 5.2}{75.5 - 5.2} = .10, \text{ or 10 per cent.}$$

The peanuts were dried for 49 hr. By dividing the total drying time in hours by the number of hours in one time unit, the number of time units was obtained: 49/5.8 = 8.45 time units. The values of 8.45 time units and 10 per cent moisture content ratio were referred to Fig. 1 of Hukill's article(4) and a depth factor of 5.9 was read from the chart.

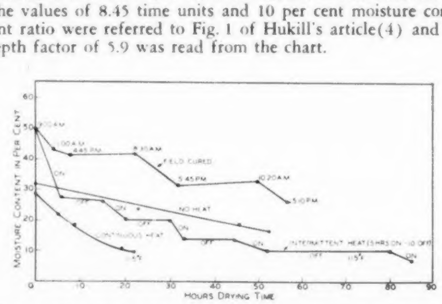

Fig. 6 Comparison of a typical intermittent drying curve, a continuous drying curve, a drying curve where natural air was used alone, and a field-curved drying curve

In order to determine the weight of peanuts per depth unit, the following formula was used:

$$G = \frac{Q \times 60 \times \Delta T \times S_a \times H}{0.01 \times \Delta M \times V}$$

where G = pounds of dry matter in a layer one unit deep

Q = volume of air in pounds per minute

ΔT = the maximum temperature drop that may occur in the air

S_a = specific heat of air at constant pressure which may be taken as 0.24 Btu per pound-degree

H = the time in hours required for fully exposed grain to reach halfway to its equilibrium moisture

ΔM = the total possible change in moisture content of the grain—the initial moisture minus equilibrium moisture (per cent dry basis)

V = latent heat of drying, Btu per pound of water.

These values were measured to be $Q = 34.4$; $\Delta T = 115 - 82.5 = 32.5$; $S_a = 0.24$; $H = 5.8$; $\Delta M = 75.5 - 5.2 = 70.3$, and V, assumed to be 1100 Btu per lb. Substituting these values in the formula

$$G = \frac{34.4 \times 60 \times 32.5 \times .24 \times 5.8}{0.01 \times 70.3 \times 1100} = 120.7$$

gave the pounds of dry peanuts in each depth unit. As there were 5.9 depth units, 5.9 x 120.7 = 712.1 lb of dry peanuts were computed to be in the bin.

The measured weight of the peanuts was 740 lb containing 6.3 per cent moisture. This amounted to 740 — (740 x 0.063) = 693.4 lb of dry peanuts. The difference in the measured and computed values was 712.1 — 693.4 = 18.7 lb, or 2.7 per cent.

Although there was close agreement between the measured and computed weights, it should be pointed out that the value used for time unit was an average value. Had some of the extreme time units that make up this average been used, the computed weight would have varied from the measured weight by as much as 150 lb. Subsequent determinations of time units failed to supply a consistent value. It is believed, therefore, that due to this variance, the use of this formula as a means for solving a peanut-drying problem should not be relied upon for any except general calculations.

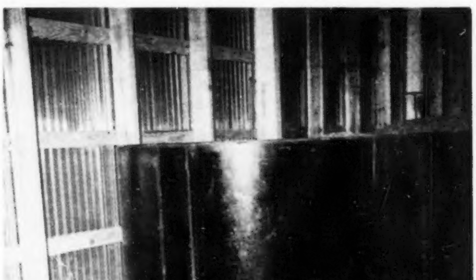

Fig. 7 Details of air gate in the W. A. Womack bin-type seed drier

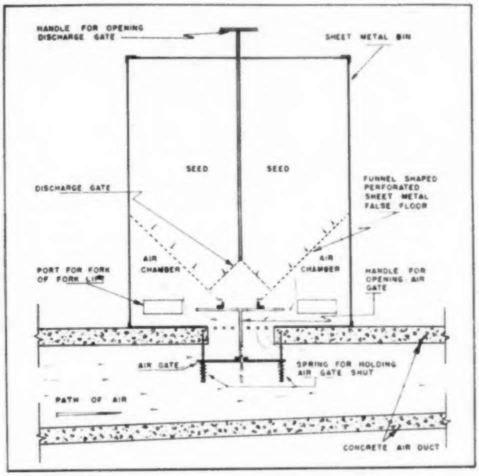

Fig. 8 View of an air vent and some of the drying bins of W. A. Womack's bin-type drier

Several observers have reported an increased rate of drying due to intermittent drying procedure(1, 3). The theory is that by drying the shells, then allowing the peanuts to "rest" for a certain length of time, moisture will move from the nuts to the shells resulting in a greater moisture differential between the shell and the drying air, thereby producing more efficient drying. Fig. 6 shows a typical intermittent drying curve, a continuous drying curve, a drying curve where natural air alone was used, and a field-cured drying curve. Considerably more moisture was removed during 25 hr of drying time by intermittent drying than by continuous drying at the same temperature. Where the initial moisture content of the peanuts was approximately the same, there was consistently less time required for drying intermittently than continuously, although the difference was not as pronounced as that shown in Fig. 6. Some factors not yet thoroughly investigated, however, are the economics of tying up a drier during the long "rest" period while permitting the shells to absorb moisture from the nuts and the danger of internal damage caused from allowing warm, high-moisture-content peanuts to set for long periods of time. It may be possible to rotate the peanuts from a drier to storage bins and then return them to the drier.

Types of Driers Used. Peanuts have been artificially dried in Alabama by several different methods during the past few years. They have been dried in column driers(1, 7), driers of the rotary-kiln type, batch-type driers, and in sacks over air ports. Some have been dried before and after shelling.

At an average temperature of 100 F, 11,795 lb of shelled peanuts were dried from 9 to 7.8 per cent moisture in 2.5 hr in the column drier owned by W. A. Womack, Rocky Creek Farms, Ashford, Ala. In filling the tall drier, the long fall through the baffles in the drier caused many of the nuts to break open. Inasmuch as these peanuts were oil stock, this was not a severe disadvantage.

Shelled peanuts were dried in a batch-type drier from 11.8 to 7.1 per cent moisture in 5.5 hr at a temperature of 107 F. The fan was operated an additional 3 hr to cool the nuts. The cost of drying one ton of nuts was 69c including heat

losses and was based on 12c per gal of propane gas and 3c per kw-hr of electricity.

Shelled peanuts in sacks were stacked around air ports approximately 18 in square. The sacks were filled and sewn so that practically no shifting of seed in the sack was possible. Five different methods of stacking the sacks were employed and all tests run for the same period of time. In one test, sacks were stacked several tiers deep in a hollow square arrangement around the port and were capped off by two other sacks. These peanuts weighed 3.1 per cent less after drying. In another test, the sacks were stood upright in a hollow circle around the port and capped off. The weight loss by this method was 4.7 per cent. Where a slatted floor arrangement was set over the port and covered with sacks lying flat, the weight loss was 3.7 per cent. A similar slatted floor arrangement with sacks stacked upright produced a 3.6 per cent reduction in weight. The final test involved only three sacks, two placed side by side lying down and centered over the port and the third centered over the first two. The weight loss in this instance was 2.8 per cent. Many of the sacks were sampled and it was found, in general, that the nuts nearest the drying air were driest. The total drying time was 4 hr. It is believed that peanuts dried in sacks will vary in moisture reduction more due to care in stacking and sealing than in the method of stacking. The circular arrangement appeared best, probably because the sacks were lapped at the thin outer edges and a more uniform thickness of nuts resulted from this method of stacking than any other tried.

THE TYPES OF DRIERS USED

The bin-type drier of Mr. Womack's was used to dry rain-soaked peanuts of many neighboring farmers during 1948. This drier consists of an underground air duct lined and covered with concrete. Round metal drying bins, 4 ft in diameter and 5 ft high were placed over vents about 18 in square in the top of the air duct. The bins were equipped with guards to depress spring-loaded gates in the top of the air duct when the bins were placed on the vents. The gates opened when the bins were in position over the duct, but closed automatically when the bins were moved by a fork-lift truck for loading or unloading the crop. Fig. 7 is a schematic view showing the operation of this air gate, and Fig. 8 is a view of an air vent and some of the drying bins. Three lots of peanuts dried by Mr. Womack were tested for free fatty acids before and after drying. Analysis showed no significant increase. The drying air temperature was 115 F and there were about 15 tons involved in the three tests.

A rotary-drum-type potato dehydrator belonging to James Foster of Luverne, Ala., was used to dry one lot of water-logged peanuts, which would have been a complete loss in a few days. The burner of the dehydrator was adjusted to the lowest flame possible to reduce the temperature. In spite of this, the discharge temperature of the peanuts after about 20 min in the dehydrator was approximately 170 F. Clouds of water vapor were given off by the peanuts for several minutes after leaving the drier and the kernels had a blistered appearance. After cooling, samples of these peanuts contained 11 to 17 per cent moisture and were valued at between $160 and $180 per ton by a local peanut buyer.

Cost analyses were made on a batch-type drier to determine the cost of fuel required to maintain a temperature of 115 F in the air entering the peanuts and the cost of electricity to operate the blower. Depreciation, interest, labor, etc., were not included in the analysis. These computations included the following factors: drying time, temperature of drying air, temperature of atmospheric air, and total volume of air delivered by the blower. Using propane gas costing 12c per gal as a source of heat and charging electricity at 3c per kw-hr, it was computed that unshelled peanuts could be dried from 43 to 6.3 per cent moisture content for $4.27 per ton; from 13.1 to 10.4 per cent for 28c per ton; from 17.2 to 9.4 per cent for 76c per ton, and from 31 to 9.7 per cent for $1.71 per ton. These costs are based on 100 per cent efficient operation of the drier, a situation that will exist in theory only. However, by dividing these values by the probable efficiency of a drier, say, 70 per cent, an estimate of the cost of curing may be obtained. The efficiency of the drier used in these tests did not exceed 55 per cent.

TABLE 1. COST COMPARISON OF COMMON FUELS AT CURRENT RETAIL PRICES IN ALABAMA

Kind of fuel	Basis of cost calculations	Btu per unit	Cost of 1,000,000 Btu	Ratio compared to propane gas
Natural gas	$ 0.30/1000 cu ft	1,000/cu ft	$0.300	0.23
Coal	15.00/ton	14,000/lb	0.535	0.41
Fuel oil No. 3	0.11/gal	139,000/gal	0.781	0.60
Kerosene	0.15/gal	134,000/gal	1.120	0.86
Butane	0.12/gal	102,400/gal	1.170	0.89
Propane	0.12/gal	91,800/gal	1.306	1.00
Gasoline	0.25/gal	129,000/gal	1.938	1.48
Electricity	0.015/kw-hr	3,415/kw-hr	4.395	3.36

In order to compare the cost of various fuels sold in Alabama, Table 1 was developed. The cost per million Btu was based on average retail prices in the state. The basis for the calculations and the heating values assumed are shown in the table. Costs of fuels requiring a heat exchanger should be divided by the efficiency of the exchanger.

SUMMARY

Peanut drying in Alabama is recommended only as insurance in the event of unfavorable weather rather than as a routine farm-to-market process, until conclusive data showing improved quality or increased yields due to high-moisture harvesting are available.

Peanut shells dried more rapidly than the nuts during the early stages of both field and artificial curing. On the other hand, the shells did not dry to as low a moisture content as the nuts, because they have a higher hygroscopic equilibrium moisture content.

The drying time was reduced as the temperature of the drying air was increased, other factors being equal. Overdrying with the resultant skin slippage and breaking open of nuts were disadvantages caused by high-temperature drying. The effect of various drying-air temperatures on quality are being investigated.

The moisture removed at various depths in two batches of peanuts using two rates of air flow was shown. Zone drying was shown to occur, and the effect of increasing the air flow on the drying zone was described. An air flow that produced drying in all layers of peanuts within 12 hr was selected as that necessary to dry peanuts containing 50 per cent moisture without damage. This air flow was 121.8 lb of air per minute per ton of dry peanuts. It was explained that less air flow would be required if the peanuts contained less moisture initially.

Hukill's method of analyzing a drying process was used to compute the weight of a batch of peanuts. This computed weight varied from the measured weight by 2.7 per cent. The time unit factor used in the equation was found to vary considerably during a season. Variations in the time unit were shown to have considerable effect upon the solution of a drying problem.

Intermittent drying was shown to reduce the total time of drying when compared with continuous drying. The question was raised as to the economics of keeping the drier inoperative during the waiting period of an intermittent process and the possibility of internal damage in the nuts due to such curing procedure.

Several types of driers that have been used to cure peanuts artificially in Alabama were described. These include rotary-kiln-type driers, a column drier, batch-type driers, and drying in sacks stacked around air ports. Drying tests were conducted with both shelled and unshelled peanuts. The moisture reduction and cost for some of the drying methods were discussed. A comparison of the cost of various fuels in Alabama was made.

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(Continued on page 32)

Method for Measuring Flow in Open Irrigation Channels

By Roy T. Tribble
MEMBER A.S.A.E.

AN EASY method of determining the rate of flow in open channels is desirable to those responsible for laying out irrigation systems. The concrete flume system of water distribution, now used on many sugar plantations, must be removed from the fields at harvest and relaid at planting, while level ditches are destroyed and must be rebuilt to grade. An irrigation system should be adequate yet as small in size as possible to permit economy in its removal and reinstallation. An easy method for measuring rate of flow has many advantages in studying the roughness characteristics of channel linings and the selection of channel sizes at turnouts and changes in grade. Furthermore a simple method will help irrigators to establish a better criterion for estimating the rate of flow in distribution lines.

Measurements of the rate of flow of irrigation water in main and lateral ditches have been accomplished primarily by weirs and Parshall flumes, of which the sizes and capacities have been determined by hydraulic formula and revised from time to time by actual field experience. Current meters are used quite often in large channels for observation work. However, where flow rates are taken daily or several times each day, current meters have been replaced by weirs or Parshall flumes. The latter utilizes an instrument actuated by a float to record the rate of flow continuously.

There are a number of ways by which the rate of flow may be determined in small channels. However, the velocity-area methods are considered more practical for field distribution lines. Each method has some advantages and disadvantages. The current meter is very effective in large streams but impossible to use in small channels, due to turbulent flow and recesses (outlets) in flume walls; floats are believed to be very inaccurate; the pitot tube, though accurate for work in the laboratory, is limited by turbulent flow and the time required to cross section the channel; the color method is rapid and easy to apply but depends upon one's ability to observe the beginning and end of the added colored matter; apparently, the salt-velocity method is the most accurate and practical for measuring the rate of flow in small channels.

Allen and Taylor*, measuring flow in penstocks, obtained curves showing a variation of electrical conductivity with time as the salt passed the observation section, and refer to the theoretically correct center of gravity of the curve as the point to which time should be taken. As illustrated by the curves, using this point for time measurement is subject to considerable error. It may be shown that under ideal conditions time should be measured to passage of the center of gravity of the added salt. This is not the same as the time to the center of gravity of the conductivity-time curve, but the difference is small.

This paper was prepared expressly for AGRICULTURAL ENGINEERING and published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper 199.

The author: ROY T. TRIBBLE, assistant agricultural engineer, Hawaii Agricultural Experiment Station, Honolulu.

* Allen, Charles M. and Taylor, Edwin A.: The Salt-Velocity Method of Water Measurement.

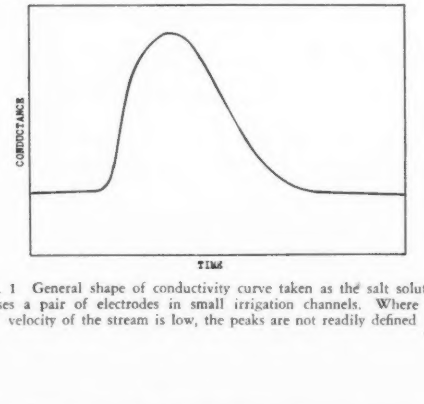

Fig. 1 General shape of conductivity curve taken as the salt solution passes a pair of electrodes in small irrigation channels. Where the velocity of the stream is low, the peaks are not readily defined

The accuracy of these measurements appeared to depend on the length, along the time axis, of the conductivity curve, and its shape. Their test data indicate that where the duration of the curve is short and the peaks are well defined, little variation is present between the quantity measured by weir and that computed using the center of gravity of the conductivity curve or the peak of concentration. On the other hand, considerable variation is present where the duration of increased conductivity is long and the peak of concentration is not well defined. Considering the weir measurements to be correct, the error in the salt-velocity method was from -0.14 per cent to $+4.98$ per cent using peaks of concentration and -0.95 per cent to $+1.10$ per cent using the center of gravity of conductivity curve (depending upon the location of the electrodes within the channel). The test data indicate that if the electrodes are placed at some point of average velocity in the channel then the error in measurement, using the peak of concentration or center of gravity of conductivity-time curve would be ± 0.5 of one per cent and ± 0.3 of one per cent, respectively. Other factors which influence the variation in quantity of flow are the method of salt injection, size of shots, and the concentration of salt solution.

Obviously to obtain the concentration curve and then to determine its center of gravity requires considerable time and equipment. It appears that measurements to the passage of maximum concentration are sufficiently accurate for field conditions.

The salt-velocity method has been used successfully in determining the roughness coefficient of wood, earth, concrete, and metal irrigation flumes. Equipment used consisted of an ohmmeter with an extension cord to a pair of electrodes, a solution of salt† and water, stop watch, and a means of determining the cross-section area of the stream. The electrodes were formed by removing 2 to 3 in of insulation from each of the wires in the extension cord. A clamp was used to secure the electrodes in the proper position.

The ohmmeter was located at the point where the salt was to be added and the electrodes were placed a distance equal to 60 per cent of the depth from the surface of the water and 100 ft downstream. A small amount of salt solution was then poured into the stream and time was taken to the minimum reading of the ohmmeter. Distance was measured from the point where the salt was added to the location of the electrodes.

The cross-sectional area of the channel may be determined by several methods depending on the degree of accuracy required. The concrete flume is molded and consequently varies little in size. A measurement of the depth of water flowing in a flume of known dimensions plus the average velocity on a uniform slope is sufficient for determining the rate of flow. This method of calculating the rate of flow is sufficient for foremen or other personnel responsible for distributing irrigation water to various parts of the farm or plantation.

In determining the roughness coefficient of flume materials, I measured the distance from top to bottom of the flume and to the water level at 1-inch intervals and plotted the channel and water line measurements. A Polar planimeter was used to determine the cross-section area of the stream. Usually several stations were incorporated and the average slope, velocity, cross-section area of stream, and water perimeter were used to compute the roughness coefficient.

(Continued on page 32)

† The salt may be sodium chloride, ammonium nitrate or any of the soluble fertilizers.

Computing Excavation and Capacity of Dugout Ponds

By Benjamin Isgur

DUGOUT ponds have become very popular in various parts of the country and are used extensively for stock watering, irrigation, fish, and as a means of storing water for fire protection. Considerable mathematical computation is needed to determine the volume of material to be excavated. These computations must be repeated many times over for any individual pond when the farmer or engineer wants to know how much water remains in the pond at various depth stages.

Commonly dugout ponds are built with bulldozers and have the sides sloped at 2:1 and the ends sloped at 4:1. The accompanying chart may be used for rectangular-shaped reservoirs to calculate the volume of excavation necessary to make such a reservoir. Also this chart may be used to calculate the volume of water at various stages of depth.

I have developed the following generalized formulas for making up charts to use in determining the volume of excavation for any combination of side and end slopes for dugout ponds.

$$\text{When } \frac{S_s}{S_l} > \frac{r_l}{r_s},\ V = \frac{4 r_l r_s h^3}{3} + r_s C h^2 \quad . \quad . \quad . \quad [1]$$

$$\text{When } \frac{S_s}{S_l} < \frac{r_l}{r_s},\ V = \frac{4 r_l r_s h^3}{3} + r_l K h^2 \quad . \quad . \quad . \quad [2]$$

Where $\begin{cases} S_l = \text{long side} \\ S_s = \text{short side} \\ r_l = \text{slope of long side} \\ r_s = \text{slope of short side} \end{cases}$ $\quad C = S_s - \dfrac{S_l r_l}{r_s} \quad K = S_l - \dfrac{S_s r_s}{r_l} = \dfrac{C r_s}{r_l}$

The C curves in the chart for formula [1] may be used for the K curves in formula [2] if it is remembered that the K curve is the same as the Cr_s/r_l curve.

For dugouts with variable slopes there will be a limiting value for the ratio of sides S_s/S_l beyond which the C values for curves are no longer valid. It is therefore necessary to set up another chart with K values for this condition. However, since $K = Cr_s/r_l$, the one chart may be used and each C curve can also be given a K value.

The following is proof of the formulas used:

Where S_l = long side
S_s = short side
r_l = slope of long side
r_s = slope of short side

$$C = S_s - \frac{S_l r_l}{r_s} \qquad K = S_l - \frac{S_s r_s}{r_l}$$

h = depth of pond at which two opposite sides meet

(1) When $\dfrac{S_s}{S_l} > \dfrac{r_l}{r_s}$,

$$A = S_l S_s = (2 r_s h)(2 r_l h + C) = 4 r_l r_s h^2 + 2 r_s C h$$

$$V \int_h^0 = A \partial h = \int_h^0 (4 r_l r_s h^2 + 2 r_s C h)\, \partial h$$

$$V = \frac{4 r_l r_s h^3}{3} + r_s C h^2$$

(2) When $\dfrac{S_s}{S_l} < \dfrac{r_l}{r_s}$,

$$A = S_l S_s = (2 r_s h + K)(2 r_l h) = 4 r_l r_s h^2 + 2 r_l K h$$

$$V = \int_h^0 A \partial h = \int_h^0 (4 r_l r_s h^2 + 2 r_l K h)\, \partial h$$

$$V = \frac{4 r_l r_s h^3}{3} + r_l K h^2$$

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author: BENJAMIN ISGUR, district conservationist, Soil Conservation Service, U.S. Department of Agriculture, Northamption, Mass.

AUTHOR'S NOTE: The author wishes to acknowledge the assistance of George Decker, agricultural engineer, Soil Conservation Service, USDA, in drafting the curves for the chart on the opposite page.

Measuring Irrigation Flow

(Continued from page 31)

The amount of salt to be added may be determined by trial and error. However, in small streams of less than 2 cfs, 50 cc of a 25 per cent solution was used with good results. The amount depends, primarily, upon the rate of flow, size of channel, and whether the flow is uniform or turbulent.

Measurements of stream velocity by timing the progress of a small amount of salt solution depend for their accuracy on the average velocity of the salt being the same as the average velocity of the water. Turbulent flow mixes the salt with the water as it moves downstream, and a question arises if some point in the spreading salt solution may be taken as indicative of the average velocity of all the salt.

It is observed that the electrical conductivity at any section of the channel rises and falls with the passage of the salt according to a skewed curve, that is, steeper is front and tailing out behind, as would be expected from the distribution of velocities of water flowing in a channel (Fig. 1). Electrical conductivity is closely proportional to the concentration of salt in dilute solutions.

As previously indicated, distance was measured from the point at which the solution was added to the point at which the electrodes were located. It is probable that during the first few feet of its travel most of the salt was near the center of the stream and was traveling faster than the average velocity of the water. The steep front and long tail of the conductivity curve would make the time measured to passage of the maximum conductivity a little shorter than the time to passage of the center of gravity of the added salt. These effects would reinforce each other in making the salt velocity determinations too high. A check of the salt solution measurements against flow measurements by other methods does not show the salt solution results to be consistently too high, consequently, it was concluded that other errors are more important than those due to the method of measuring the velocity of the salt.

Artificial Curing of Peanuts

(Continued from page 30)

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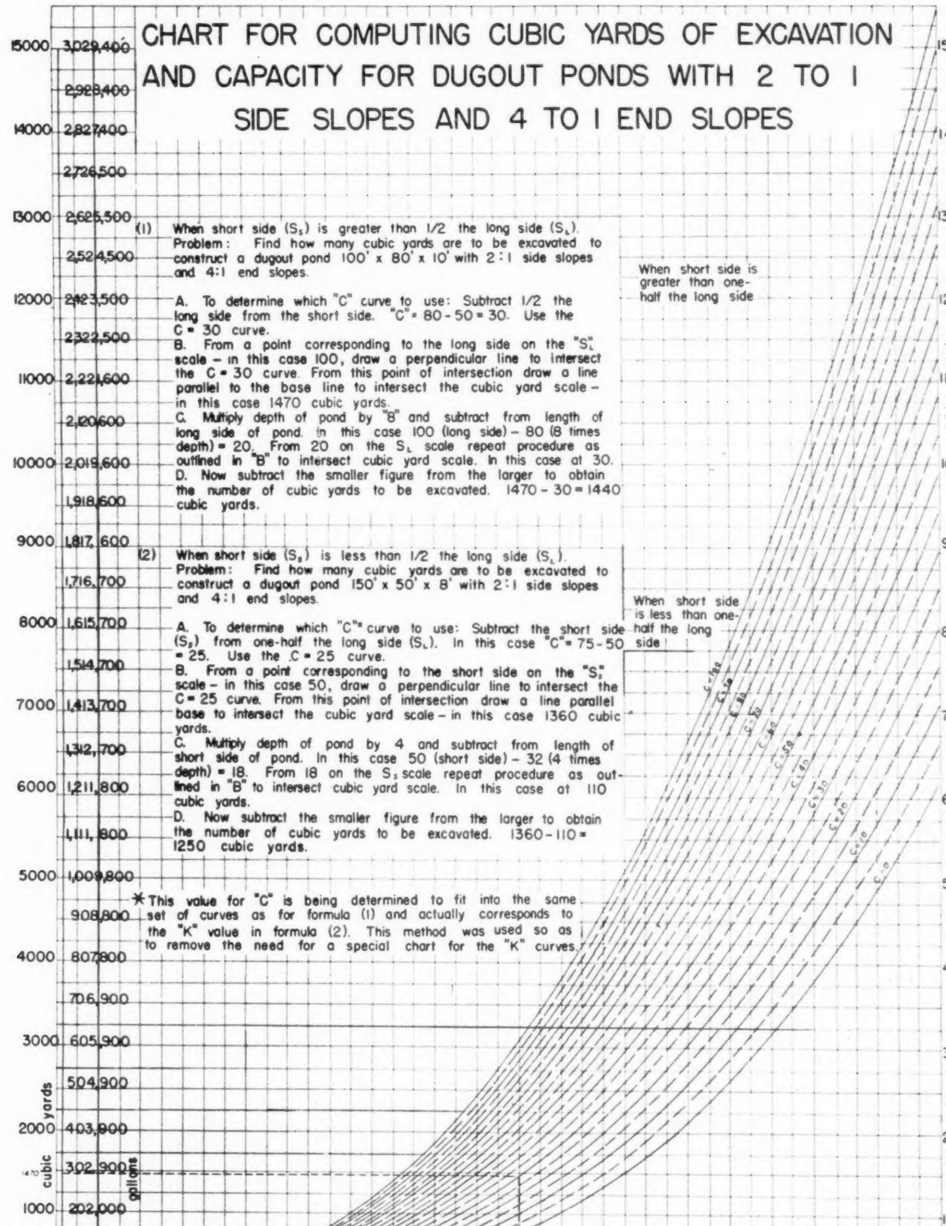
CHART FOR COMPUTING CUBIC YARDS OF EXCAVATION AND CAPACITY FOR DUGOUT PONDS WITH 2 TO 1 SIDE SLOPES AND 4 TO 1 END SLOPES
(1) When short side (S_s) is greater than 1/2 the long side (S_L).
Problem: Find how many cubic yards are to be excavated to construct a dugout pond 100' x 80' x 10' with 2:1 side slopes and 4:1 end slopes.
A. To determine which "C" curve to use: Subtract 1/2 the long side from the short side. "C" = 80 - 50 = 30. Use the C = 30 curve.
B. From a point corresponding to the long side on the "S_L" scale – in this case 100, draw a perpendicular line to intersect the C = 30 curve. From this point of intersection draw a line parallel to the base line to intersect the cubic yard scale – in this case 1470 cubic yards.
C. Multiply depth of pond by "8" and subtract from length of long side of pond. In this case 100 (long side) – 80 (8 times depth) = 20. From 20 on the S_L scale repeat procedure as outlined in "B" to intersect cubic yard scale. In this case at 30.
D. Now subtract the smaller figure from the larger to obtain the number of cubic yards to be excavated. 1470 - 30 = 1440 cubic yards.
When short side is greater than one-half the long side
(2) When short side (S_s) is less than 1/2 the long side (S_L).
Problem: Find how many cubic yards are to be excavated to construct a dugout pond 150' x 50' x 8' with 2:1 side slopes and 4:1 end slopes.
A. To determine which "C"* curve to use: Subtract the short side (S_s) from one-half the long side (S_L). In this case "C" = 75 - 50 = 25. Use the C = 25 curve.
B. From a point corresponding to the short side on the "S_s" scale – in this case 50, draw a perpendicular line to intersect the C = 25 curve. From this point of intersection draw a line parallel base to intersect the cubic yard scale – in this case 1360 cubic yards.
C. Multiply depth of pond by 4 and subtract from length of short side of pond. In this case 50 (short side) – 32 (4 times depth) = 18. From 18 on the S_s scale repeat procedure as outlined in "B" to intersect cubic yard scale. In this case at 110 cubic yards.
D. Now subtract the smaller figure from the larger to obtain the number of cubic yards to be excavated. 1360 - 110 = 1250 cubic yards.
When short side is less than one-half the long side
* This value for "C" is being determined to fit into the same set of curves as for formula (1) and actually corresponds to the "K" value in formula (2). This method was used so as to remove the need for a special chart for the "K" curves.
cubic yards
gallons
short side (S_s)
long side (S_L)
cubic yards
15000 3,029,400
2,928,400
14000 2,827,400
2,726,500
13000 2,625,500
2,524,500
12000 2,423,500
2,322,500
11000 2,221,600
2,120,600
10000 2,019,600
1,918,600
9000 1,817,600
1,716,700
8000 1,615,700
1,514,700
7000 1,413,700
1,312,700
6000 1,211,800
1,111,800
5000 1,009,800
908,800
4000 807,800
706,900
3000 605,900
504,900
2000 403,900
302,900
1000 202,000
500 101,000
30 0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
15000 14000 13000 12000 11000 10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 500

A Method of Determining the Latent Heat of Agricultural Crops

By George L. Gallaher
ASSOCIATE MEMBER A.S.A.E.

WITH the amount of research work being done on drying of agricultural crops, it is desirable to have adequate values for the amount of heat required to evaporate water from them. The latent heat of free water, as given in the steam tables, has been used to a great extent. In many cases, however, especially with crops at low moisture content, its use results in considerable error.

Several methods of determining the latent heat are available. Of course, it can be obtained directly by careful experiment. Othmer(1),* however, has devised a convenient method using vapor pressures. When good equilibrium moisture-content data are available, Othmer's method is quite simple and useful for agricultural crops. It is based on the Clapeyron equation:

$$\frac{dP}{dT} = \frac{L}{(V-v)\,T} \qquad [1]$$

where P is the vapor pressure in pounds per square foot, T is the absolute temperature in degrees Rankine, V is the specific volume of water vapor in cubic feet per pound, v is the specific volume of liquid water in cubic feet per pound, and L is the latent heat of vaporization in foot-pounds per pound.

In his paper, Othmer establishes the following formula from equation [1]:

$$\log P = \frac{L}{L'} \log P' + C \qquad [2]$$

where P and P' are pressures and L and L' latent heats, respectively, of two substances always taken at the same temperatures. C is a constant of integration. For agricultural crops, it is most convenient to use L and P for water vapor from the crop and L' and P' for free water vapor. This expression then shows that, if the log of the pressure of the crop is plotted against the log of the pressure of water at the same temperature, the resulting line will have for its slope the ratio of the latent heat of the crop to the latent heat of free water. The constant C is eliminated in solving for the slope of the line. The slope equals

$$\frac{L}{L'} = \frac{\log P_2 - \log P_1}{\log P'_2 - \log P'_1} \qquad [3]$$

where the subscripts 1 and 2 represent any two points on the line.

The equilibrium-moisture-content data for wheat, published by Gay(2), can be used to illustrate this method and establish the latent heat of wheat. From curves faired through his data, the equilibrium-relative-humidity can be read at various temperatures and moisture contents. By multiplying these humidity values by the saturation-vapor pressure for the given temperature, the required values of wheat vapor pressure are obtained. Table 1 gives wheat vapor pressures computed in this manner for moisture contents from 10 to 18 per cent (dry basis) and temperatures from 50 to 100 F. Fig. 1 shows these vapor pressures plotted against the vapor pressure of free water on a log-log plot. They give reasonably well-defined straight lines.

TABLE 1. VAPOR PRESSURE FROM WHEAT, IN POUNDS PER SQUARE INCH (Computed from data in Reference 2)

Moisture content per cent dry basis	Temperature, deg F 50	60	70	80	90	100
10	—	—	0.076	0.124	0.192	0.292
11	0.045	0.070	.108	.170	.255	.379
12	.061	.094	.142	.214	.317	.462
13	.079	.119	.176	.261	.384	.555
14	.102	.152	.222	.318	.449	.626
16	.125	.182	.261	.367	.511	—
18	.135	.196	.280	.393	.545	—
Free water	.178	.256	.363	.507	.698	.949

The slopes of the lines in Fig. 1, namely, the ratios of the latent heat of wheat to the latent heat of free water, have been plotted as the ordinate in Fig. 2. *(Continued on page 38)*

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author: GEORGE L. GALLAHER, instructor in agricultural engineering and junior engineer in the agricultural experiment station, University of California, Davis.

*Numbers in parentheses refer to the appended references.

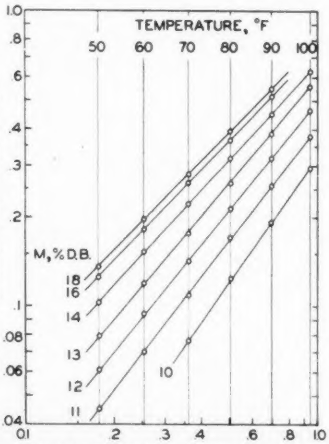

Fig. 1 Vapor pressure log-log plot

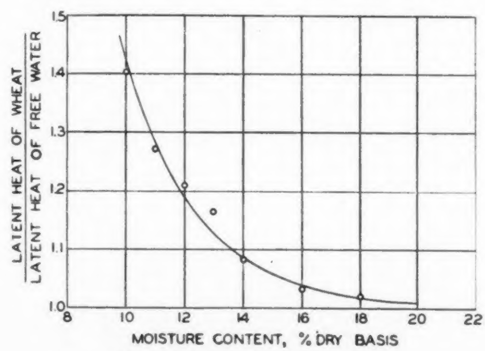

Fig. 2 Variation in latent heat of wheat

Equipment for Grassland Farming

By Frank N. G. Kranick
LIFE FELLOW A.S.A.E.

GRASSLAND farming is a general plan of farm operation calculated to combine quick-return advantages in forage, livestock production, and land-use efficiency, with long-range advantages in soil conservation. In recent years it has gained substantial acceptance in livestock production and soil erosion problem areas.

On all farms the acreage of sloping land which should be kept in grass all or most of the time is more than can be effectively used for pasture. High protein legumes and other forage crops must be harvested from some of it to provide feed for the livestock which can be carried by the remainder during months of good pasture, and which is otherwise desirable in the farm operating plan. This implies forage crop production, harvesting, hauling, handling, conditioning, storage, and feeding operations which, to be done economically, must be implemented by power machinery and other modern facilities. As with most of man's mechanisms, this equipment in its present state of development leaves room for improvement. It is believed, therefore, that a short summary of information and ideas on the functional requirements of equipment for grassland farming will be of special interest and value to many agricultural engineers.

General Requirements. It is evident that field machines for grassland farming should be well-adapted to hillside operation.

There is considerable room for improvement in ease and speed of attaching and detaching tractors from the variety of equipment units needed in grassland farming.

Additional time of considerable value to farmers could be saved by design of machines to reduce frequency of lubrication and other routine maintenance.

Mowers. Grassland farming imposes no really new functional requirements on mowers. It emphasizes the importance of the time factor, as to state of maturity of the crop. Where field-drying methods are used, the time factor is also critical in relation to weather. Machine elements for performing supplementary operations on freshly cut crops are being combined with mowers to an increasing extent.

Ground-driven mower units offer an advantage under some conditions in that two or more of them can be pulled in tandem behind a tractor with sufficient power capacity, and can be attached and detached in a minimum of time and with ease. Their power requirements and capacity per foot of cut compare favorably with those of power-driven mowers.

Cutter-bar locations and swathboards commonly place the swath where it will be run over by the front wheels of a tricycle-type tractor on the next round. This tends to compress the swath and force it down into the stubble and close to the ground, so that drying is delayed. The relation of wheel paths to swath position needs further consideration.

Mower power from a constant-running power take-off, and with an available low ground speed of about 1½ mph at full power would be desirable for some heavy crop conditions and for use on borders and terraced fields, but these features may not be justified where this would be their primary use.

Hay Crushers. This equipment, usually combined in the form of mower-crushers, has reached a state of development in which it does a mechanically satisfactory job of crushing stems without damaging the leaves. The result is a substantial saving in time and weather risk in field drying, and in time in artificial drying. Units commercially available at present represent a high investment cost which minimizes their net advantage for limited use. It seems likely that lower-cost units, adapted to economic use in operation on a smaller scale, will be developed.

Side-Delivery Rakes. Many of these are ground-driven machines in which the raking cylinder speed is automatically related to ground speed so that a desirable windrow is formed with minimum movement and damage to the hay. In power-take-off-driven models now becoming available, the cylinder speed is not directly related to ground speed, depending to an extent on the tractor used. These models involve increased investment cost and hitching and unhitching time. There is need for study of these machines to find what leaf damage is done at higher travel rates.

Forage Harvesters. Influence of silo filler design is evident in forage harvesters. The recent trend of progress has been in the direction of making these machines handle a wider variety of grass and forage as well as row crops, and dry or partially dry hay as well as fresh-cut green material. Further improvement for the more gentle handling of dry and partially dry hay, with cut lengths up to 6 in or longer, with increased capacity and with elevation to wagon and storage by some means requiring less power than blowers or throwers, seems in order. A study of this problem of elevating the chopped dry hay by different means might give us direction in providing a minimum of leaf loss.

One machine for handling the ear corn crop differs a little from the forage harvester, and yet has some of its good points. This machine cuts the cornstalk close to the ground, removes the ear from the stalk, and the husk from the ear, and conveys the ears to a wagon box drawn behind the machine. The stalk, the husks, and the leaves are cut and shredded and pass out of the rear of the machine as stover. This may be collected in another wagon box and hauled to the barn as bedding when straw is scarce. At any rate it makes plowing easier and some cheaper. This machine, also, since it processes the whole stalk, saves the shelled corn and delivers it to a bag without loss on the ground.

Isn't it likely that this idea will grow since it reduces large waste of ear and shelled corn? It also retards the corn borer. Perhaps we shall soon find it possible to do this job even more completely by shelling the corn in the field to save another handling and shelling operation. Means are being found to dry such corn economically.

Balers. Baling is useful to prepare hay for sale and delivery off the farm, and sometimes to conserve storage space, even at some expense in quality. It appears that more baling for storage is being done in some areas than is warranted by limitations of storage space, with little regard for its influence on feeding quality.

The conventional plunger-type baler, unless operated by an expert, is a means that may reduce the quality of the hay due to its mechanical design. Many custom operators, and there are thousands of them, are more interested in what they get for doing the job, than in the quality of the product that is produced.

When a hay crop in a locality is ready to cut, nearly every farmer in the area would be doing the same thing, and the custom baler operator cannot do all these jobs on the same day, so that some hay must wait either in the cutting or drying process until a baler can be procured, and in the meantime the hay suffers in quality.

There is ample evidence that the hay is not handled very gently in some of this baling operation. The dust which is so common and so disagreeable in this operation is sufficient evidence that something is happening to the product that is not improving its value. Close observation in the field following a pickup baler will very often reveal that there is considerable opportunity for improvement to increase the over-all efficiency of these machines.

This is an abstract of a paper presented at a meeting of the Joint Committee on Grassland Farming, at Chicago, Ill., December, 1949.

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It might be a splendid experiment station project to evaluate the performance of present balers to get some facts on efficiency. It is not so much a matter of bales in numbers or acres or man-hours or power consumed, or even price translated into costs per ton baled, but on the actual performance and the production of a good hay. What does some baling do to good hay? It cannot make it better. It can make it worse. It is certain that we shall not change the functions of the machines we now have unless we are sure that there is need for change. It is a difficult task, and an expensive one, to make a change in a piece of farm equipment, or in anything else for that matter, and unfortunately many of us are victims of habit, and it is with reluctance that we make changes.

Since many farmers seem to prefer to handle and store hay in baled form, there appears to be justification for work to improve the over-all efficiency of pickup balers; to reduce their damage to the hay baled; to reduce investment cost so that they could be used on smaller quantities of hay in optimum condition for baling, and to improve hay crops and cropping programs so that hay could be cut and baled in optimum condition on a staggered schedule over a longer period.*

Bale Loaders and Elevators. High labor requirements are apt to be encountered in bale handling, even with the best of available equipment. With field loaders, a driver and a man to pile bales on the load are the ordinary minimum. Transferring the load to an elevator at the barn will again require individual handling of each bale, and the same will be true if the bales are stacked in storage. With bales weighing anywhere from 70 lb up to as high as 120 lb it is easily seen that it is hard and heavy hand work, not limited to this process of putting it in storage but also in taking it out, for it means more hand handling to get this hay down and into a manger or feed bunk ready for animal consumption. Bales invite further attention to labor-saving methods of handling.

Buck Rakes. These offer particular advantages in low investment cost and high-capacity handling of long hay on short hauls. For this reason they offer particular advantages for use on grassland farms. They are well adapted in combination with grapple forks, slings, or stackers. Their apparent advantages suggest further study with a view to fullest development of those advantages, and reduction of their disadvantages, such as leaf loss and their limitations.

Wagons. Hauling forage from field to barns and the associated loading and unloading operations, are important direct influences on delivered yield and cost. Because of the amount of peak work time involved, these operations may also reduce the percentage of crop which a farmer can get harvested at the optimum stage of its development, and during favorable weather.

Functional requirements of the hauling unit vary from the rack for dry long hay or the large bulk box for dry field-chopped hay, to the high-tonnage-capacity box for green chopped forage and the flat bed for bales. Optimum load capacity will be influenced by hauling distance, field conditions, grades, turns, and clearances. Modifications in detail may be required by loading and unloading equipment, rate capacity of elevators at the unloading point, and wagon-mounted or built-in unloading devices. General requirements also include good stability on sidehills and a short turning radius.

In considering the addition of unloading equipment to individual trucks or wagons, the investment cost must be considered in relation to the number of hauling units required to provide adequate hauling capacity and permit effective use of other labor and power equipment in the field and at the unloading point, as well as its influence on the value of the unit for other hauling jobs throughout the year. A study of this operation will reveal some facts that might influence design of these wagons and even the elevating blower design.

Elevating Blowers. However effective blowers may be in elevating silage, or grain in some cases, a legitimate question remains as to their effect on the feeding value of hay. More information from actual tests is needed, as to the extent to which blowers separate leaves from stems and the extent to which they reduce feed components to dust-sized particles. Study is needed on the influence of these units on ease or difficulty in getting the feed delivered to and consumed by livestock with minimum waste, and the influence of its physical condition on the nutritional value of the feed consumed by various classes of livestock. Power requirements too are factors worthy of study which might lead to other ways with which to do the job.†

Structures. It is readily evident that storage facilities have an important bearing on the series of functions and over-all efficiency with which feed values grown in June are conserved and put to use the following January. Prime considerations, in addition to shelter, capacity, and stability, are ease of getting forage into and out of the structure, and means of controlling the moisture content, and resulting chemical and bacterial action and temperature, within practicable limits.

Economics. Many agricultural factors enter into the over-all economy of grassland farming. These include providing good pasture for forage harvesting by livestock for a maximum number of days per year, and stocking with grades of livestock capable of making effective use of forage. We are concerned here primarily with the over-all economy of operations necessary to harvest, handle, store, and feed the forage needed to supplement pasture. It involves farm operations on a large-volume, large-tonnage, critical-time basis on organic chemical material with perishable components of nutritional value which are notably sensitive to environmental temperature, moisture, and oxygen supply. Its forces, dimensions, positions, physical conditions, motions, controls, human and power operations, time element, dollar values, and influence on national food economy suggest it as a major opportunity for the further application of engineering principles in and for agriculture.

Suggested Research Projects. It has become a well-established principle in agricultural engineering research that public service agencies should concentrate on research to produce fundamental data, principles, and methods, and that the detailed design and development of equipment to help farmers apply new knowledge in practice should be left to farm equipment manufacturers.

Some subjects on which further research by public service agencies might produce additional *(Continued on page 43)*

*The 1948 USDA Year Book (page 165) contains this statement: "Mechanical losses vary considerably, depending on the method of handling the forage and the type of equipment used. The shedding of leaves is the most serious loss because they contain most of the feed nutrients. Leaves generally do not shatter to any great extent when the forage contains 35 to 40 per cent or more of moisture. Therefore, forage for artificial dehydration and for barn finishing can be handled without serious loss of leaves in the field. The problem of leaf shatter, of course, is much more serious with legumes than with grasses, or with mixtures of grasses and legumes. Field baling may also promote leaf shattering, since, if the forage is dried sufficiently to prevent mold development, it is dry enough to allow easy leaf shedding. Field dried forage should be handled as little as possible and with as few machines as possible."

†Circular No. 361, College of Agriculture, University of Kentucky (page 4) has this statement: "Carefully conducted tests have shown that about 15 per cent of the weight of various legume crops usually is lost in haymaking even when the weather is favorable and crops are well handled, and that with unfavorable weather and poor handling the loss frequently runs to 50 per cent. This loss comes mostly from the shattering of leaves per unit of weight and the leaves contain twice as much protein and four times as much vitamin A as the stems. For the United States as a whole it has been estimated that in alfalfa haymaking alone, there is an annual loss of 1,326,000 tons of dry matter containing 257,000 tons of crude protein." This statement will be found in USDA Bulletin MP 363: "There seems to be no doubt that millions of dollars are lost each year through unfamiliarity with certain important principles involved in the making of high-grade hay. The opinion justified that the feed value of the hay crop could be improved fully 25 per cent by cutting at the right stage and by proper curing, handling, and storage to preserve the quality without materially increasing cost of production. In many instances the most economical way to increase the farm feed supply from hay would be to improve the quality rather than to increase the acreage."

Planning Water Disposal for Minimum Maintenance

By L. D. Worley
MEMBER A.S.A.E.

THE planning and application of water-disposal measures on agricultural land are among the major soil conservation problems in the Southeast. Water disposal is the base on which all other practices are built. If this part of the job is done properly, the subsequent maintenance will be reduced.

A water-disposal system is the device for controlling runoff from the top of a slope to base grade with a minimum of erosion. Planning a water-disposal system involves consideration of a number of factors. These include: (a) land use, (b) outlets, (c) terrace location, (d) terrace direction, (e) row layout, (f) farm road location, (g) fence location, and (h) crop rotation.

Broadly speaking, there are four major land uses: (a) cropland, (b) grassland or pasture, (c) woodland, and (d) wildlife areas. In planning a water-disposal system, one of the first factors to consider is the land that needs to be terraced. This paper will deal primarily with cropland, since this is the land for which water-disposal systems are generally designed.

Land steeper than 5 or 6 per cent slope is too steep to terrace and should be employed for one of the other land uses, depending on the farmer's needs. In making this statement, we are considering farms where two or four-row cultivators are used on terraced land. In some sections of the country, where one-row cultivators are still employed, slopes up to 8 or 10 per cent may be terraced and cultivated very satisfactorily.

There is some land of less than 5 or 6 per cent slope that should not be terraced, owing to rough topography. On this type of land it is difficult to fit a system of terraces to the uneven slopes and obtain a satisfactory row pattern.

Another condition involved in proper land use is found in the so-called critical slopes within an area of generally terraceable land. Usually these are relatively small areas, but too steep to terrace. Such areas should be planted to some type of permanent perennial vegetation. Terraces should be located just above and below these critical slopes.

After the land use has been determined, planning of outlets is the next consideration. Natural depressions should be used for meadow outlets. Sometimes disposal areas have to be used when depressions do not extend to the top of the slope or when property lines or public roads prevent the use of natural depressions for meadow outlets. In designing meadow outlets and disposal areas, the first consideration is to build the outlets large enough to take care of the expected runoff from a given area. Another consideration is the economic return expected from the area. Outlets have a two-fold use—(a) to take care of the water from the area involved and (b) for hay or seed production. When hay is to be cut or seed harvested from meadow outlets, they should be at least 20 ft wide to provide convenient and economical use of farm machinery. The outlets must be deep enough to give adequate terrace and row drainage.

Under normal conditions, 12 to 18 in is sufficient depth to give good drainage for terraces and rows. Many depressions already have sufficient depth but extreme care is needed in preparing the seedbed and applying fertilizer to secure a satisfactory stand of adapted grasses and legumes. Where sufficient depth is not found, the depressions must be deepened and shaped as needed.

In narrow depressions, shaping may be done by plowing out the area and leaving the deadfurrow in the lowest place. This type of construction is best suited to narrow depressions because the soil will not have to be moved far to blend with the existing slope of the draw.

In depressions that are wide and shallow, the outlets may be shaped by plowing the soil into the lowest place, making two small channels. This is known as the W ditch. This type of outlet is usually designed for slopes under 3 per cent and should be protected with vegetation. The spreading of soil is eliminated by the W ditch. Where depressions are not well defined, this type of outlet works very well. The W ditch is also adapted on bottomland where surface drainage is needed.

Locating the Terraces. Too often we have been guilty of running terrace lines without giving much consideration to

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Soil and Water Division.

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Fig. 1 (*Left*) This is what happens when terraces are built across natural depressions. All natural draws should be used as terrace outlets • Fig. 2 (*Right*) This meadow outlet takes the water from a 100-acre field. This is a safe water-disposal and is used for hay or seed production

fitting the terraces to the land. In locating terraces more consideration should be given to slope changes, erosion conditions, and topography. When due consideration is given to these three factors, the initial cost of terrace construction and the cost of maintenance will be reduced considerably. Many times, when we start at the top of a slope to locate terraces, the terraces cross eroded spots and gullies, and the first terrace is located too far down the slope. When this occurs, the cost of construction and maintenance will be considerably higher than if terraces were located just above these breaks. This is the case because there is considerable fill needed where the terraces cross eroded spots and gullies. Maintenance also requires more work because of the silt which accumulates in the terrace channels. Better alignment of terraces and rows is obtained by locating the terraces just above eroded spots, gullies, and slope changes.

Terraces should always drain from the ridge to the nearest natural depression. This causes the terraces to be short and uniformly spaced, with fewer short rows. When terraces are laid off to drain from the natural depressions, the terrace spacing is wide in the depressions and narrow near the ridges. One of the main reasons for this is the difference in slopes at the depressions and between the depressions and the ridges. The water will move in the direction the terraces are laid out, and some 8 or 10 rows up from the terrace channels the water will flow to the lowest place in the depressions. In other words, we have two-way traffic in the same lane. A terrace system laid out without using natural depressions will fail. One of the first things that is noticed is the ponding of water in the terrace channel in the depression. Then silt bars are noticed. The farmer will plow out the terrace channels. When another rain comes, this same thing happens. So this system of terracing has to be maintained constantly. This is the beginning of terrace benching.

A good terrace system laid out according to the natural drainage pattern of the land will assist in keeping soil in place. But a poor terrace system designed without considering the natural depressions will wash the land away.

Rows should always be laid off parallel to the terraces. We will discuss two methods of laying off rows, one for erosion control and one for drainage and crop adaptation. For erosion control lay off rows to run parallel to the terrace above and below with the short rows in the middle of the terrace interval. For drainage and crop adaptation, lay off rows paralleling the upper terrace and short rows discharging into the terrace channel below.

LOCATION OF FARM ROADS IS IMPORTANT

Many times good terracing systems are destroyed by driving farm equipment over the terraces. In planning a disposal system, the location of farm roads is an important factor. If a road system is not planned, the farmer ordinarily will use the meadow outlets or cross the terraces at a place that will block the flow of water in the terrace channel. This causes the terrace to break and gullies to form. When an outlet is used for a farm road, the vegetation usually is destroyed and gullies are started. By cresting terraces on ridges, which are well drained, the erosion hazard is reduced to a minimum. Farm roads should be located (a) on the ridge, (b) on the contour around the slope, and (c) on W ditches, where W ditches are constructed for drainage. By locating a farm road on a ridge, the farmer can enter any terrace interval without crossing a terrace. Where roads are located on steep slopes they should be vegetated.

In planning a water-disposal system, fences often have to be moved to handle the water according to the natural drainage pattern of the land. This does not refer to property-line fences, but to cross fences that are located across the slope between the ridge and the depression. Gullies often are formed along fences that are so located that a terrace system cannot be laid out to crest the terraces on the ridge and drain to a natural depression. There are three types of good fence locations that will aid in handling water and fencing for the different land uses: (a) on ridges, (b) on the contour, and (c) along the side of outlets.

Fences located on ridges reduce erosion to a minimum because the terraces and rows drain the water away from the fences.

Fences located on the contour not only aid in handling the water, but also facilitate contour farming. In many cases, moving to the contour a fence that is located across the slope, will give much longer rows for cultivation.

Where a row-crop field is on one side of the outlet and pasture or meadow is on the other, the fence should be located on the pasture or meadow side, keeping the outlet within the cultivated field. This will permit the terrace and row ends to be kept open for adequate drainage.

A water-disposal system is not complete without a well-planned crop rotation. We need plant material incorporated with the soil to increase the water-holding capacity and the rate at which the soil will take in water. We also need plant material for ground cover both as a mulch and as growing plants to reduce runoff and increase the intake of water. This ground cover, either mulch or sod, intercepts the falling raindrops and thereby reduces splash erosion.

In closing, I want to emphasize the need of a well-planned and properly applied water-disposal system. This is one of the best ways to insure good maintenance. We are aware of the fact that a properly applied water-disposal system will have to be maintained, but with less effort than a poorly planned and applied water-disposal system. We also want to emphasize the importance of designing a water-disposal system by following the natural drainage pattern of the land. By this we mean utilizing natural depressions as outlets and draining terraces from the ridges to the nearest natural depressions.

Method of Determining Latent Heat of Agricultural Crops

(Continued from page 34)

The curve drawn through the points has the following equation†, where M is the moisture content in per cent dry basis.

$$\frac{\text{Latent Heat of Wheat}}{\text{Latent Heat of Free Water}} = 1 + 23\,e^{-.40M} \qquad [4]$$

This graph shows that the amount of heat required to vaporize a pound of water from wheat increases considerably as the moisture content of the wheat decreases. Makower(3) made similar plots and obtained like results for moisture in dehydrated eggs.

The accuracy of the equilibrium data is quite important for such latent heat calculations. Some slight discrepancies in the wheat data are evidenced by the fact that the slopes do not plot as a smooth curve in Fig. 2. The points do give good straight lines in Fig. 1, however. Because of this tendency to form straight lines, such a plot as Fig. 1 provides a very good means of fairing in and extrapolating experimental data.

It also should be pointed out that the equilibrium data must be obtained for several temperatures in order to get latent heat information by Othmer's method. If equilibrium-moisture-content versus relative-humidity curves coincided for different temperatures, the latent heat would not exceed that of free water. That is, the lines in Fig. 1 would be parallel with a slope of unity.

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†This formula was obtained by plotting the points on semilog paper and obtaining the best straight line through the points by the method of least squares.

Farm Drainage and Drainage Acts in Ontario

By F. L. Ferguson and C. G. E. Downing
MEMBER A.S.A.E.

ONTARIO is a large province covering approximately 223 million acres and extending from the 42nd parallel on the south to the 56th parallel on the north. This northern boundary is just at the southern part of Hudson Bay making the extreme distance from south to north approximately 1,000 miles. From west to east, Ontario extends from the eastern boundary of Manitoba, which if extended south would be about the middle of Minnesota, to the Quebec boundary or about midway in New York state, also a distance of approximately 1000 miles. It is true that the northern part of this area is valuable very largely for mining, timber, pulpwood, game preserves, hunting, fishing and power development on many streams. Much farming is carried on in the middle section which compares in geographical location with northern Minnesota, North Dakota and the upper peninsula of Michigan.

It is, however, the area below this central section commonly referred to as southern Ontario, with which this paper is concerned. This area is south of a line from Sault Ste. Marie, North Bay and Ottawa to Montreal, all of which is well south of the 49th parallel. The drainage work north of this, which although quite considerable, consists of open-ditch work largely intended for northern Ontario development.

The southern boundary of this section, the 42nd parallel, if extended eastward would pass along the southern borders of New York and Massachusetts. If extended westward to the Pacific coast it would just touch the northern boundary of California. It is this location along with the moderating effects of the Great Lakes which surround this area that makes possible the production of a great diversity of crops.

Fruits. The fruit-growing areas are generally concentrated along the borders of the lakes. No attempt is made to separate the various fruit crops for the different areas; however, the following table will illustrate the diversity and production for the year 1949. Small fruits such as raspberries, strawberries, blueberries, etc., are not included. They are grown generally throughout the southern area.

Total acreage all fruits	86,900 acres
Apples produced	1,092,500 bbl
Peaches produced	1,237,900 bu
Plums produced	326,000 bu
Pears produced	400,000 bu
Grapes produced	15,450 tons

Tobacco. Flue-cured and Burley tobaccos are grown rather extensively as soil types in these areas lend themselves to this crop. Approximately 87,700 acres were planted in 1949 for a yield of 128,500,000 lb. The bulk of the Burley is grown on the clay soils of Essex and Kent Counties, while the flue-cured is grown on the sandy soils of Norfolk and Elgin.

Vegetables. Vegetable crops are grown generally throughout the province and as market gardens constitute about 250,000 acres.

Field Crops. General crops such as grains, hay, potatoes, turnips and mangels, are grown extensively throughout the area and account for about 9,030,200 acres.

All of this from the standpoint of drainage is very important. Our fruit and market garden areas all require extensive and generally intensive drainage; flue-cured tobacco lands require very little, the mixed farming and special crop areas for corn, soybeans, sugar beets and potatoes which are adjustable to various soils, locations and weather conditions require degrees of drainage varying from intensive systematic to a few drains located here and there to pick up the wet areas.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1949, as a contribution of the Soil and Water division.

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The following drainage acts of the province have special bearing on the work which is carried on. Some give financial assistance and others provide for legal procedure in reference to obtaining outlets.

The Provincial Aid to Drainage Act. This act is very short, but has a wide application. Briefly it makes provision for the provincial government to make a grant of 33⅓ per cent to all drainage schemes constructed under an engineer's report, regardless of the cost of the work. In the province where so many drainage ditches and large drainage projects are constructed, including diking and pumping, the Act is of valuable financial assistance.

The Municipal Drainage Aid Act. Although the province contributes to the cost of constructing drainage works, there is always a considerable outlay which must be absorbed by the owners of the properties affected. Frequently the farmer does not have the necessary funds to pay cash and credit must be arranged. Under the Municipal Drainage Aid Act the township council may sell debentures to the province to pay for the work. An assessment is then made against the properties concerned and small amounts are collected year by year until the debentures are retired. This makes it possible for many farmers to enter into a scheme without having to make a heavy cash outlay at one time.

The Ditches and Watercourses Act. Satisfactory outlets for drainage areas are often problems. Frequently these are small and at times concern only one person. Under the Ditches and Watercourses Act one man can start procedure and get relief. Generally it involves more than one, but the work which can be performed under this act is somewhat limited, but usually liberal enough to get the necessary relief. The ditch must not cross through or into more than seven township lots; land lying farther than 150 rods from the beginning or sides of the ditch cannot be assessed and it must not cost more than $2500.

The party requesting the ditch must send notices to all parties concerned asking them to come to a meeting at the site of the ditch, where they must try to come to an agreement with regard to its construction. That is, whether it should be an open ditch or a tile drain, and how much each one should do or pay and be responsible for maintaining. If such an agreement is reached, it is drawn up and signed by each party concerned. A copy is filed with the township clerk and it becomes a legal document and can be enforced the same as an engineer's award. If an agreement is not reached, the party requiring the ditch files a requisition with the township clerk to have an engineer sent in. In this case there is no option—the engineer must be sent. He makes his survey and awards each party so much of the ditch to construct. Maintenance is also established. Due time is left for appeals to be made. These are heard before a Court of Revision, and if necessary a county judge. There is generally a time limit set for the construction of the work.

The Municipal Drainage Act. Outlets for large areas frequently must be considered. These are provided for under the Municipal Drainage Act. There are no restrictions with regard to cost, area or type of work which might be undertaken. Ditching, rock-blasting, diking or pumping can be done under this act. Usually a number of men are interested. A petition is circulated and as many signers as possible are secured of those who are actually benefited by the ditch. This petition is then handed to the township council. They appoint an engineer who makes a survey of the entire watershed, estimates the costs and assesses each one concerned for outlet, benefit, or possibly both. A day is set for the reading of the engineer's report. If after hearing this report the majority benefited are still in favor the council is authorized to proceed with the work. Time of course must be allowed for appeals to be heard before a court of revision, the county judge or possibly a higher court. Having thus

cleared the way the township calls for tenders and is responsible for getting the work done. Maintenance when necessary is also the responsibility of the township council. It is completed and assessed back in the same proportions unless for some reason a new assessment is necessary.

The Tile Drainage Act. Tile-drainage improvement should be regarded as an investment and not as an expense. It so happens, however, that many farmers requiring drainage do not have the money to invest and the province has very ably come to their assistance by means of the Tile Drainage Act. The province has authorized an investment up to $3,000,000.

This money is obtained through the township council. They pass a by-law to establish a credit with the provincial government. The individual township can borrow as high as $200,000. If their total assessment is $3,000,000 or over, they can borrow $300,000. Some 98 townships in Ontario have passed the necessary by-law. Having completed this requirement they are in a position to accept application from the individual farmer. A farm owner can borrow 75 per cent of the cost of his work up to $3,000 per 100 acres or fraction thereof. He receives this on a 3 per cent interest rate over either a 10 or 20-yr period. It is worked out on an amortization plan. For every $100 a man borrows, he pays $11.72 a year for 10 yr, or $6.72 a year for 20 yr to repay his loan with interest. By passing a by-law the township sets the necessary assessment against his property and this appears on his taxbill. If he sells his property, the buyer has the privilege of helping to pay for the drainage work. He may at any time discharge the entire debt if he so desires.

When the farmer is satisfied by the township that he can get a loan, he proceeds with his work. When completed the township inspector makes a report on the costs of the work. From this report the amount of money for his debenture is calculated. The debentures have the necessary coupons attached. These are clipped off by the provincial treasurer's office as they come due and are sent up to the township treasurer for payment, so the whole procedure becomes automatic.

The question of a mortgage on a farm should be mentioned. This loan has prior rights on a man's property and hence comes ahead of a first mortgage; consequently it is necessary to get the mortgagee's consent before a loan is advanced.

This act was passed in 1878 and without exception since 1879 loans have been made every year. For a number of years the loans were light. About 1910 and 1911 the Agricultural College at Guelph became interested in helping the farmers. Survey work was started, demonstrations and meetings were held, the farmers learned that they could borrow money under the Tile Drainage Act and in 1913 power machinery was introduced. Drainage work received a real inpetus. More loans were requested and a lot more land was drained. Total loans made up to the end of 1949 have been about 5½ million dollars. The maximum loans made in any one year being $375,000. The greatest drainage activity was between the years 1920 to 1932 in which time approximately one-half of the total loans were made. There has been general advancement in drainage activities during years of good farm prices and following wet years. The recessions in the activities have been during years of poor farm prices, dry years and during wars and depressions.

Assistance in Drainage Projects. As mentioned above, the Department of Agriculture through the Agricultural College started a program of giving farmers assistance with their drainage projects. This has been carried on and increased until today the province is roughly divided into four districts with a permanent man located in each. To take care of extra work third-year students from the Ontario Agricultural College at Guelph are hired for the summer. These men make surveys, draw up plans and specifications for installation work, and give advice on all manners of drainage problems.

Completed plans are usually left with the farmer for installation purposes. Any changes or corrections are made and the farmer supplied with a blue print of his work for his permanent records.

There is a small charge made for this work. It is varied according to the size of the job — a $5 charge for a hundred acres survey being used as a standard.

When requests are made the fieldmen also act as inspecters and check levels on the drains as installed and before backfilling. Any backfall or improper grades must then be corrected. This is considered one of the most important phases of the work. There has been great variations in the amount of faulty installations. In some districts and in certain years these have been noted as high as 60 per cent of those inspected. It is perhaps not as serious as it would appear. One or two bad spots might occur on quite a large project which would label the installation as faulty, whereas for the amount of work done it was perhaps only a small percentage of the work which was affected. There has been a very noticeable increase in poor work from 1943. This is due in some respects to the difficulty in obtaining operators during the last two years of the war, to the inexperience of those who were obtained, and to the introduction of new machines with inexperienced operators. It might also be added that those in charge of inspections tightened up a little on the necessary requirements. This assistance assures the farmer of good work, and his tile, if so installed, should continue to give satisfaction for years to come.

Reference has already been made to the factors affecting tile drainage loans year by year. It is also interesting to correlate it with some other factors.

Fig. 1 shows the correlation between the number of surveys made in any year and the spring precipitation. Rainfall appears to be the basis of drainage activity. Note how the fluctuations in surveys made lags about one year behind the fluctuations in precipitation. This holds very true except for the early war period, when help was not available to meet all the requests for assistance.

Fig. 1 also shows the surveys made and the percentage installed within the year that the (Continued on page 43)

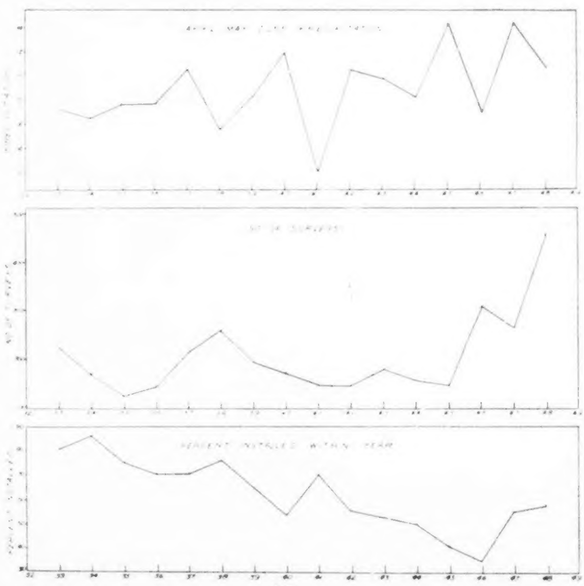

Fig. 1 Correlation of survey and drainage activity with spring precipitation

Distribution of Air in Refrigerated Apple Storages

By W. Grierson-Jackson

THE material presented in this paper represents a condensation of results obtained in a survey of the apple and pear storages of British Columbia, Canada, carried out in the period between May, 1947 and September, 1949.

This investigation was essentially a survey to endeavor to (a) improve air circulation in existing storages and (b) formulate principles whereby future storages might be built with some certainty of efficient air distribution.

Hitherto most of these storages had been built with two sets of experts each attending to their own fields; the architect and contractor attending to the fabric of the building and a refrigeration company installing machinery guaranteed to produce a given number of tons of refrigeration. The matter of distributing this refrigeration has, only too often, been left in the hands of well-intentioned people who were only too often gravely handicapped by a lack of any real training or experience in the difficult business of distributing refrigerated air evenly and economically, without damage to the delicate tissues of living fruit. As a result, a quite astonishing number of different systems for distributing cold air to warm fruit had been installed in these storages. Air was being "squirted" at high pressures and "sprinkled" at low pressures. In too many systems attempts were being made to pipe it around like water. The purpose of this study was to find which systems were most efficient.

The approach to the problem was purely empirical and from the most elementary aspects possible. In most of these storages the duct system was studied from the inside, entering at the fan room and crawling through the entire system. (In many storages this necessitated breaking into the ductwork, no inspection port having been left). Then with the storage empty and the air distribution system running, a systematic plot was made of air movement throughout the whole storage. This was done by releasing puffs of smoke and plotting their movement on a scale diagram. Then, with the direction of air movement known, the velocities were measured with an Alnor velometer.

It was found that the air circulation in an empty room gave a very clear indication of movement in the loaded room. Also it gave a very good pointer to warm and cold areas. (Both air movement and temperatures were checked later with the rooms loaded, a thermocouple set-up being used to measure temperatures within the stacks).

In all, 27 storages were studied. This was made possible by the fact that all these storages belong to the same organization, the British Columbia Fruit Growers Association. The Association put up the necessary funds, every storage in the province was automatically available for study, and the storages themselves carried out all experimental alterations at their own expense. Obviously it is impossible to present in this short paper all the data obtained, much of which is already available in a prior publication.* Instead, a number of conclusions as to general principles will be advanced, together with some of the experimental data on which they are based.

*Grierson-Jackson, W. and Fisher, D. V.: Forced Air Circulation in Fruit Storages. *Refrigerating Engineering*, vol. 57, nos. 7 and 8 (July and August 1949).

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Washington, D.C., June, 1950, as a contribution of the Farm Structures Division.

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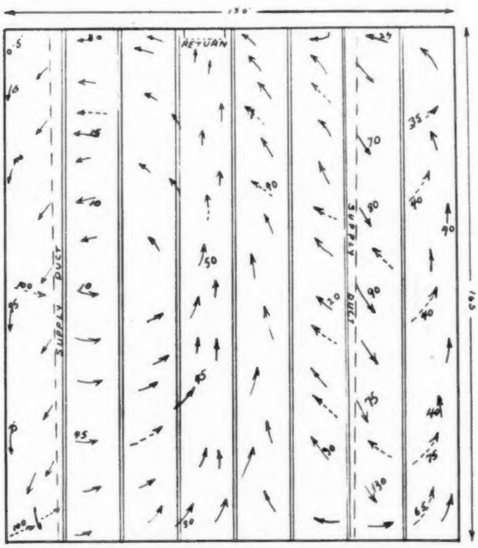

Fig. 1 Actual plot of air circulation in a room with one delivery duct on the beam next to the wall and the other on the second beam from the opposite wall. Discharge velocities were higher than advisable. Broken arrows represent circulation at floor level; solid arrows, circulation at stack height

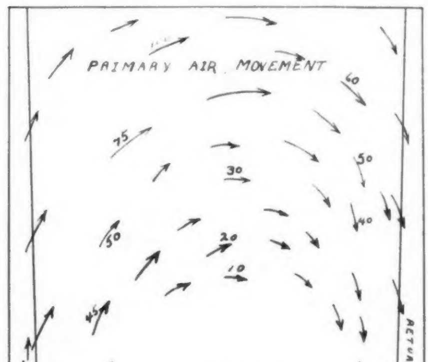

Fig. 2 Circulation in a room having a supply duct down one side and a return duct on the other. Both had unbaffled and ungraduated vents. Figures indicate typical velocities in feet per minute

Type of Air Distribution System. In all, 11 different types of air-distribution system were tested. They varied from extremely efficient to grossly inefficient. Within broad limitations it can be said that the simpler the system the more efficient it was. In almost every circumstance the "twin-delivery duct, central return well" type proved as efficient as any and cheaper than most. The principal fault of this system was that the corners nearest the fan tended to be starved for air, with a disproportionately great amount of air going to the corners distant from the fan. This was not difficult to correct by (a) putting scoops on the vents nearest the fan, and (b) having vent size decrease with distance from the fan. Fig. 1 shows how unequal air distribution to the corners can be if these measures are not taken.

One very common type of system is to have a delivery duct on one wall and a return duct on the other. The supposition is that the air moves uniformly across the room. Fig. 2 shows what was actually found to happen in a storage of this type, and consequently confirmed in numerous similar rooms. The pulldown period in such rooms was sometimes a matter of months. This is quite understandable since the whole center of the room had to be cooled, not by forced-air movement, but largely by convection.

Velocity of Discharge. Efficient air distribution systems were found working on two quite different principles: (a) high-velocity discharge, in which the air leaves at a velocity of 1000 fpm or more and is driven forcibly to where it is wanted; and (b) low-velocity discharge, in which the air is discharged into the room at a low velocity of 600 fpm or less and then led where wanted by slight pressure differentials within the room itself.

The former system was found to be very effective in large palletized plants with their high 22 ft or more ceilings and wide clear areas free of posts, beams and other obstructions. Fig. 3 shows such a storage. This particular room is 140 x 112 x 22 ft with a single row of posts and no ceiling beams. This plant was later fitted with jet-type vents, Fig. 4.

Fig. 5 shows a very different type of storage. Fig. 6 shows the effect of such ceiling beams on air discharged at even a moderate velocity. It will be perceived that a 12-in beam is not only sufficient to cause a sharp downdraft, but effectively reverses the direction of movement on the other side of the beam. This downdraft was several times found to be a contributory cause of freezing of fruit.

Fig. 7 shows how these effects can be avoided. The figure shows a cross section through a room having twin-delivery ducts on the outermost beams and a central return well at the end of a central trucking aisle. The space at the walls acts as a plenum and the central aisle acts as a very slight vacuum with a resultant even flow through the stacked fruit. This was only found to be effective if an adequate space was left at the walls (8 in was usually effective) and the discharge from the vents was slow enough not to build up any considerable velocity along the wall away from the fan. Also, it is necessary to have the air return judiciously placed. In one storage of this type uneven temperatures were quickly traced to an air return through the ceiling midway along one sidewall.

Type of Air Return. Multiple-opening return ducts were found to cause more trouble than any other single factor. The only ones that were found to draw air at all evenly along their length were quite elaborately built ducts in a Hukill-type† reversing air system. Most return ducts tested behaved as shown in Table 1 which shows actual figures on two multivent tapered return ducts.

TABLE 1. PERFORMANCE OF TWO MULTIVENT TAPERED RETURN DUCTS.

(All openings are of equal size and vent No. 1 is nearest to the fan. Figures are intake in cubic feet per minute.)

Vent No.	1	2	3	4	5	6	7
Duct 1 . . .	1,330	800	475	260	130	130	125
Duct 2 . . .	1,090	755	430	260	105	84	75

†Hukill, W. V. and E. Smith: Cold Storage for Apples and Pears, USDA Circ. No. 740, 1946.

It will be noted that only the first three vents are really effective. *In several storages hundreds of feet of return duct were found in which absolutely no air movement could be perceived.* In all these storages, tearing out the return ducts and substituting simple well-type return openings with a trucking aisle leading from them gave much better results.

Many storages had return-well openings high up in order to draw on warmer air. Particularly in small rooms, this practice was found to be actually harmful. This was due to the fact that the cold air was discharged at ceiling level, tended to circulate entirely above the stacked fruit and enter the return duct directly. In one series of small 20 x 20 ft

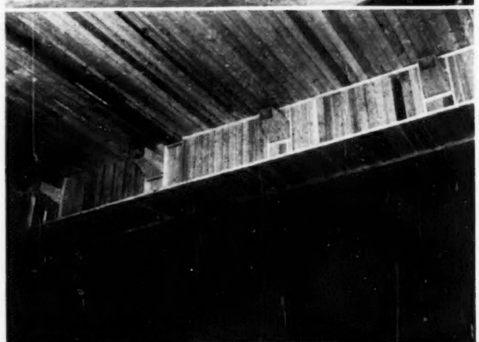

Fig. 3 *(Top)* Large 200,000-box palletized storage. Very suitable for high-velocity air distribution. (See also Fig. 4) • Fig. 4 *(Center)* Same storage as in Fig. 3, but showing the use of jets. Note that the air thrown from these jets is completely unimpeded by beams, joists, etc. • Fig. 5 *(Bottom)* Extreme case of a clutter-up storage. A clear case for extremely low-speed air delivery and a circulation pattern based on pressure differences. (Photos by J. E. Britton)

rooms, lowering the air return opening to the floor raised the air circulation at floor level from 0-5 to 15-25 fpm with a consequent beneficial effect on temperatures.

Balancing Air Distribution. A rapid movement of air through ports and doors, either between rooms or to the outside, soon came to be recognized as a symptom of poor air distribution. Any movement to or from the outside is an obvious loss of refrigeration. In many storages air was being lost at rates as high as 2,000 cfm per open doorway (e.g., 100 fpm through a 3 x 6½-ft doorway). Many attempts were being made to check this by means of canvas flaps and various kinds of swinging or sliding doors. The best protection was found to be an efficiently balanced air-distribution system in which the air return from each room is exactly proportional to the air being delivered.

One storage was having such trouble with leakage at doorways and conveyor ports that the refrigeration to the first floor was often cut off during loading periods. Investigation showed that with refrigeration running normally, the fourth floor leaked to the third floor, the third to the second and the second to the first (ground) floor. Three doorways into the first floor used for loading leaked inward at an average velocity of 130 fpm, a total inward movement of approximately 8,000 cfm of warm air when all three doors were loading.

Decreasing the return from the first floor by 25 per cent and increasing the return from the second floor by approximately 10 per cent eliminated most of the trouble. After this there was negligible movement between floors and an outward movement at the loading doors of 10 to 20 fpm. This loss was considered to be about minimal.

Air movement between floors is a less obvious indication of inefficiency. It does, however, indicate a lack of balance between deliveries and returns. In its acutest form it can cause a very real strain on the efficiency of insulation and vapor barriers. In one large multiroom plant a ground floor room was found to be returning only 20 per cent of the air it received. A third-floor room was found to be returning 20 per cent more than it received through the delivery ducts. Such findings indicate an extensive air movement through the insulation, since these two rooms were not connected by ports or stairways.

One large storage was very much troubled with long slow pulldown periods and occasional freezing corners. It was using the "delivery duct on one wall, return duct on the other wall" type of air circulation. It was changed over to a "twin delivery duct, central return well" system. The openings to the return well were fitted with guillotine-type dampers with actual openings 20 per cent oversize. By the use of these dampers air movement was so balanced that air movement between floors in the four-story building was reduced from over 100 fpm at the stairways to less than 10. The management were so enthused that they are repeating the system in a new storage under construction.

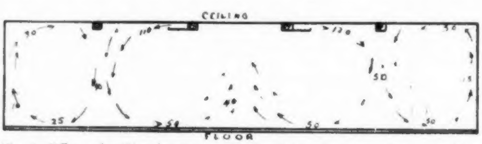

Fig. 6 Effect of ceiling beams on air circulation in an empty room. Air return is down a center aisle to a return well. Figures refer to velocities in feet per minute. (N. B. Vertical scale is greatly exaggerated)

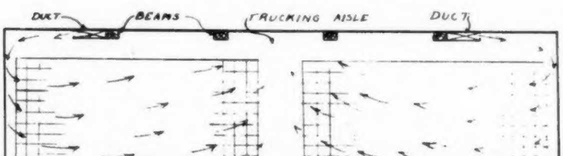

Fig. 7 Cross section of a storage room (vertical scale greatly exaggerated) to illustrate the necessity for leaving a clear space at the walls and the advantage of having the delivery ducts on the outermost beams. (Compare with Fig. 6). Return is down the central aisle to a return well

CONCLUSION

It is realized that only scanty data are advanced here to support the principles advanced. This is unavoidable due to limitations of time and space. However, I would be delighted to correspond with anyone who might be interested in going into further detail on any of the above points.

Farm Drainage and Drainage Acts

(Continued from page 40)

surveys were made. It should be pointed out here that many of the surveys made cannot possibly be installed in the same year: Sometimes it is impossible to get tile; sometimes machines are not available; and sometimes the survey was made late in the season and intended for another year. It may be several years before the tile is installed. It should, however, be pointed out that those requesting surveys do so in good faith and very few plans are made which are not used.

There are a number of low areas in the province out of which the drainage water must be pumped. These areas in total cover about 50,000 acres. Centrifugal pumps are used mainly on these projects.

This paper would not be complete without something on costs of tile installation. There is considerable variation in costs from one locality to another, depending on the type of digging, nature of the soil, crop growth, and to some extent on competition. Some areas are free of stone while in some districts large contracts are available. In fruit orchards and vineyards more difficulties are encountered and progress is usually slow. More ditching machines are available in some districts. The majority of these machines are old with about a dozen newer types being introduced since the war. Tile plants are few and widely scattered, making transportation costs high in some areas.

In general drainage costs have doubled in the last 10 years. Four-inch tile at present are costing from $35 to $50 a thousand. Ditching costs about 3c per ft under good field conditions and 5c per ft in orchards and vineyards. The total cost of tiling in the western field areas is about $70 per acre; 10 yr ago this cost was $35 per acre. In the vineyard and orchard districts present costs range from $100 to $125 per acre; 10 yr ago this cost was about $60 per acre. Ditching machines which a few years ago were purchased for $3500 now cost $10,000. This has also been a contributing factor to the increase in cost. However, as long as the farmer has good markets and good crops he will continue to drain his wet land. There is, perhaps, no money invested around the farm that pays higher dividends.

Equipment for Grassland Farming

(Continued from page 36)

information of substantial value in grassland farming, and to manufacturers of related equipment are as follows:

Factors influencing time required for connecting and disconnecting between tractors and operated equipment.

Factors influencing efficiency of side-delivery rake performance.

Influence of chopped hay handling methods on power and labor efficiency and on feeding value.

Principles of hay baling influencing economy and value of product.

Extent of leaf loss and means of minimizing it in the construction and use of buck rakes.

Functional requirements of forage-hauling units.

Influence of blowers and other types of elevating equipment on the quality of dry hay and on power consumption.

In summary, the major values to be conserved in handling forage are nutritional components, human time and energy, mechanical power, and investment costs.

Engineering Aspects of Rice Drying

By Harold A. Kramer
MEMBER A.S.A.E.

THE drying of rice is a complex process due to the varying climatic conditions under which the crop must be dried, the many different varieties of rice of varying grain size and shape, and the wide range of moisture content of rice as it reaches the driers. It is further complicated by the importance of maximum head rice yields which greatly influence the market value of a lot. Unbroken grains remaining after completion of the milling process are here referred to as head rice.

Optimum drying environments for rice of all varieties, moisture contents, stages of maturity, etc., have not been fully determined. Attempts are being made to obtain this basic information by laboratory methods and full-scale tests at commercial driers, and to determine the effect of predrying factors on the final quality of rice. After determining these optimum conditions, the engineer can design equipment which will expose, as uniformly as possible, all rice grains in a given lot to these ideal drying conditions.

For maximum quality, rice must be harvested at the proper stage of maturity. The most common measure of maturity is moisture content. Often this is not reliable due to the effect of varying weather conditions. A more reliable method is needed. Perhaps agronomists can offer visual signs of maturity for different varieties. Using moisture as a maturity index, best milling and germination results have been obtained when Zenith was harvested at from 20 to 25 per cent moisture content* and Caloro from 21 to 26 per cent moisture content. Available evidence indicates that rapid field drying of rice, immediately before harvest, in drained fields during periods of low humidity, may lower head rice yields.

At present no practical method for satisfactorily drying hulled rice is available. Many of the hulled grains check when dried, which results in lower head rice yields. In individual lots of rice received at a commercial drier in Beaumont, Texas, during the past harvest season, the percentage of hulled rice by weight ranged from 1.5 per cent to 8.2 per cent with an average of 4.9 per cent, a standard deviation of 2.0 per cent, and coefficient of variability of 41.6 per cent. At another drier 60 lots of Zenith had an average of 4.7 per cent hulled rice, a standard deviation of 2.9 per cent and coefficient of variability of 62 per cent. These percentages are probably typical of most driers. If less rice were hulled in the harvesting process, an appreciable increase in head rice yields should result.

It has been observed that when rice with excess moisture is temporarily stored overnight, or for a similar period of time, in a combine hopper or truck, it soon develops a sour odor and often heats noticeably. Observations also show that when this rice is placed in a receiving bin with other rice it increases in temperature at a faster rate. No explanation is known, but it is suggested that relative availability of oxygen may be a factor.

Laboratory drying studies were conducted using 50-g samples of rice spread one grain thick on screen wire trays. Fully exposed drying conditions were thus approached when relatively large quantities of drying air were used. Four separate drying chambers with three trays each were provided for making comparative and replicated tests. The dry- and wet-bulb temperatures of the drying air were controlled automatically to + ½ deg. Loss of moisture and final moisture content were determined by weighing to 1/100 g. Samples used for quality studies were all dried to approximately 13 per cent, and then seasoned under uniform atmospheric conditions for 30 days for milling tests and 60 days for germination.

Official milling tests were made by the Beaumont, Texas, office of the Grain Branch, Production and Marketing Administration, and germination tests were made by the Federal Seed Laboratory located at Beltsville, Md. In these studies, all foreign material and hulled rice were previously removed from the wet samples. Check samples were retained for each test and these were air-dried on screen trays for comparative quality determination.

Eighteen laboratory tests were completed for each of the varieties Caloro, Zenith, Bluebonnet, and Rexoro; and four for the variety Magnolia. These represent popular varieties of short, medium and long-grain types. Dry-bulb temperatures from 90 to 142 F were used with relative humidities ranging from 11 to 84 per cent. Air velocities of 100 and 200 fpm were used in the exposure chambers.

All milling and germination results have not been received, but it appears that the milling quality of fully exposed grains was usually lowered when drying temperatures exceeded 100 F. The data are rather scattered, but in a few instances good milling was obtained with 130 F dry-bulb temperature when the relative humidity of the heated air exceeded 60 per cent. Germination appears to be satisfactory with temperatures up to 110 F. The results show a lower milling quality where the higher velocity of drying air was used.

Bulk drying of rice at existing plants is carried out under conditions considerably different than in the laboratory. The average rice drier requires a minimum of 80 bbl of rice to fill the drying section. A blower may force from 20,000 to 40,000 cu ft of drying air through this rice each minute. Heat for drying is usually supplied by natural-gas or butane burners located at the inlet of the blower. The desired drying air temperature is maintained with automatic controls. Receiving bins are used to hold rice of separate lots until it is dried. Rice received at the drier varies considerably in moisture content.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author: HAROLD A. KRAMER, agricultural engineer, division of farm building and rural housing (BPISAE), U.S. Department of Agriculture.

*All moisture contents indicated in this paper were determined by the wet-basis method.

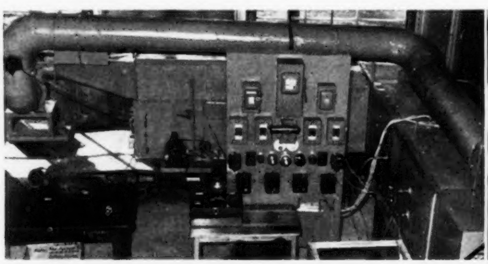

Fig. 1 *(Left)* Laboratory drier used for making replicated drying tests of rice under controlled conditions • Fig. 2 *(Right)* Sampling rice at regular intervals as it is spouted from bin, to obtain uniformity and quality of entire lot

In some cases, the grains threshed from individual heads vary from the milk stage at the base to well-matured rice at the tip. Individual truck loads also vary greatly in moisture content. This is usually due to evaporation of surface moisture during dry days, variation of maturity in the field, effect of weeds in the rice, and to rain. Truck loads will vary in size up to about 100 bbl each, and it is not unusual to find a 5 per cent variation in average moisture content in loads from the same field.

The size of lot or amount of rice received per day from one owner also varies greatly. Usually more than one combine is operated in a field. Under good harvesting conditions one 12-ft, self-propelled combine will harvest about 300 bbl per day, but it may harvest anything less than that amount due to rain, breakdowns, difficult harvesting conditions, or completion of the field.

Field conditions and the skill of the combine operator affect the amount of straw, weed seeds, and the foreign matter received at the drier with the rice. Variations in moisture, size of lot received, quality of rice, amount of hulled rice, and foreign matter in rice are important aspects of rice drying over which the drier operator has little control. He often must accept rice as it comes and try to maintain whatever potential milling quality it has.

The following remarks apply mainly to the more common continuous-flow-type rice driers such as the Berico and Hess, with which most drier operators are familiar.

It is common practice to completely empty the drier between lots and to fill the drier column and hopper with a new lot before drying again starts. Gates which would permit more rapid change of lots have not generally been popular because of the danger of mixing. Better engineering designs might overcome this objection.

When the drier column is filled, the blower is started and drying begins. After about 20 to 30 min of drying the discharge mechanism is started and rice begins to flow through the drier. If this initial batch drying was not practiced, rice at the base of the column would receive very little exposure to drying air before leaving the drier. A few drier operators begin discharging rice from the drier at the start of the exposure period and recirculate this rice back to the drier hopper for 10 to 20 min. We recommend this procedure for more uniformity of drying.

When rice is not recirculated in the drier the exposure period may be 20 to 30 min longer for part of the rice. This means that the drying will not be uniform for the entire lot. Moisture tests verify this and the bin temperature for rice with the longer exposure is about 3 deg higher.

The absolute humidity of the atmosphere in the Gulf Coast area of Louisiana and Texas is relatively high during the rice-drying season. Weather Bureau records show that during August, September, and October, 1949, the daily averages for the grains of water vapor per pound of atmospheric air were 128, 121, and 109, respectively. This is one reason why a large quantity of air is used in the drying of rice. Individual installations vary considerably, but quantities of air up to 400 cfm per barrel of rice are commonly used.

Our results indicate that the temperature of rice leaving a drier should not exceed 100 F. During the last drying season, a large number of temperature observations were made with thermocouples, of rice in bins immediately after drying. With a Berico drier, using about 400 cu ft of air per barrel per minute, an exposure period of 30 min, and an inlet air temperature of 116 F, the temperature of the discharge rice varied from about 95 to 105 F.

The question is often asked if it is necessary to dry rice more than once. From the operator's standpoint, this is a desirable procedure. During peak periods he often receives 10 to 15 lots per day from different owners, which must be dried separately. In such instances, if each lot were dried to completion in sequence, the total time required would exceed the safe limit. Also, it is usually desirable to mix rice of the same lot received on different days. The total elapsed drying time is less for rice dried intermittently. Our results do not show that continuous drying of rice at reasonably low temperatures is harmful to milling quality. Rice has been dried by constant recirculation through a continuous-flow-type drier with excellent results, and this practice is recommended for seed rice. There is less chance of contamination with other rice and no possibility of germination being injured while in the bin between dryings.

The bin temperature of rice will normally increase between dryings. The rate of temperature rise will vary considerably, but our records for rice in reinforced concrete bins, for the first 24 hr, show the following averages: under 15 per cent moisture, 46.5 hr per deg F rise; 15 to 18 per cent, 13.1 hr; and 18 to 22 per cent, 8.6 hr.

Our records indicate that rice does not normally increase in moisture content between routine dryings. Actually a slight, but probably insignificant, decrease in moisture was found when numerous tests were made of rice entering and leaving bins.

What is the ideal drying air temperature? This depends on many interrelated factors; hence, a definite answer is not available at this time. Only continued research in the laboratory and actual drying plants will give the answer. An upper dry-bulb temperature and a maximum temperature drop across the drying column may be a practical answer to this question. The upper temperature may be limited by germination loss or breakdown of oils in the rice bran. The temperature drop is an indication of the rate of drying. Research conducted in this connection has not established an upper limit for either case. It appears that a 20 to 30-deg drop across a 6-in column of rice is not detrimental to quality.

How much water can be safely removed from rice during each drying? Our results indicate that this depends on the rate of removal rather than the amount, and that continuous drying at a low rate may be better than intermittent drying at higher rates. Good results are usually obtained when less than 2 per cent is removed during a 30-min exposure period.

During the drying process the temperature of rice usually becomes higher than the normal atmospheric temperature. This condition is undesirable where rice is stored in large bins, after drying has been completed. Official milling tests have been obtained of such dry rice, which was rapidly cooled 40 F by exposure to cold atmospheric air in a rice drier. No loss of milling quality was indicated by these tests.

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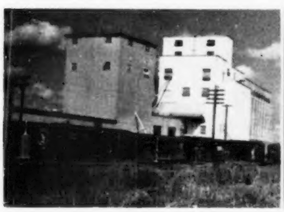
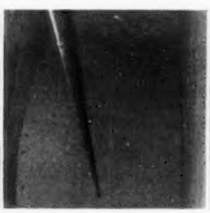



Fig. 3 *(Left)* Large cooperative drying plant where rice drying studies were conducted • Fig. 4 *(Left center)* Thermocouples were located at 5-ft intervals throughout vertical center of rice bin • Fig. 5 *(Right center)* Portable potentiometer and selector switches used to measure rice temperatures • Fig. 6 *(Right)* Samples of all rice used in the drying studies were allowed to reach equilibrium in shallow screen trays and marquisette bags before comparative quality determinations were made

Irrigation Practices in Puerto Rico

By D. K. Fuhriman and R. M. Smith
MEMBER A.S.A.E.

PUERTO RICO, the largest of the United States possessions in the Caribbean, is about 100 miles long and 35 miles wide, and has a population density of at least 615 persons per square mile*. Its economy is predominantly agricultural, supported in large measure by the production of sugar cane. Situated about 18 deg north of the equator, its climate is subtropical with an extreme seasonal variation of 10F in mean temperature, but considerable variation in precipitation, both geographically and seasonally. As a result of this variation, irrigation is necessary for crop production on much of the cane land. The island has a mountain range of mixed volcanic rocks running from east to west, rising to a maximum elevation of about 4390 ft above sea level, which has considerable effect on the rainfall distribution. The mountain areas receive 90 to 200 in of precipitation annually, and the north coastal plains usually receive from 60 to 80 in, which is sufficient for good crop production. However, irrigation is necessary over most of the fertile south coastal plain and in the area of Isabela in the northwestern part of the island.

Rainfall on the south coastal plain varies from about 25 to 50 in and open pan evaporation is close to 75 in per year. Fig. 1 shows the climatic divisions of Puerto Rico according to Thornthwaite's classification. Irrigation is largely restricted to the semiarid and subhumid areas shown on the map. It is of interest that the "wet" areas provide water for most of the storage reservoirs in Puerto Rico. An extensive irrigation project is now being planned to bring water from the "wet" mountain area in the western part of the island to the Lajas Valley in the subhumid area in the Southwest. Cane and other crops will die from lack of water at certain seasons unless irrigated.

History. Irrigation was introduced by the Spaniards about the beginning of the 19th century. The characteristic Spanish brick and rock masonry canals, flumes, and irrigation structures are in evidence at several points on the south coastal plain (Figs. 2, 3, and 4). Many are still in use today. Irrigation has been limited almost entirely to sugar cane lands which have been developed intensively since the American occupation in 1898. Although introduced at an early date, irrigation was practiced on a relatively small scale during the 19th century. Beginning about 1900, more and more of the lands of the south coastal plain have been planted to sugar cane, and irrigation has become an integral part of the sugar industry in the area. Early irrigators used the orthodox long furrow supplied from a lateral at the head of the field. The primary method of distribution in use today is the short-furrow method, actually a modified basin method, first introduced into Puerto Rico by Patrick McLane of Hawaii in about 1908. This method has been almost universally adopted by Puerto Rican irrigators. The closely spaced field supply ditches laid out under McLane's specifications to carry water to the furrows are now called by his name. Local people usually refer to a field supply ditch as a "McLane."

Present Practices. Briefly, the layout and use of the present system is about as follows: Wide and deep furrows are laid out with zero slope and are cut into short lengths of 20 to 40 ft by McLanes which run at right angles to the furrows, directly down the slope (Fig. 5). In the preparation of the field for planting, the furrows are made first. Common row spacing is 5 ft with a ridge between. In most cases the furrows at the time of planting are made about as deep as the angle of repose of the soil will allow. For example, if the angle of repose were 45 deg, then the furrow would be approximately 2½ ft deep and have a top width of 5 ft with a sharp-pointed ridge between furrows. The soil of this center ridge is worked against the stalks as the cane develops.

When the McLanes are dug, the furrows on both ends are purposely "plugged" with soil in order that the irrigation water will be impounded when it is being applied. The cross-sectional area of the McLanes is usually slightly smaller than the irrigation furrows when first laid out. However, no control structures of any kind are used, and the water is regulated by simply damming the channel with soil. As a result of this soil spading in the water, considerable soil movement takes place. The original McLane becomes wider and shallower as the season progresses, resulting in inefficient distribution and increased waste of water. The layout is not usually altered even on lands having 15 or 20 per cent slopes. As a result, the downslope McLanes approach gully proportions in some instances.

The stream of water used by an individual irrigator using this system is usually small, varying between 0.25 and 0.75 sec-ft, but usually less than 0.5 sec-ft. The entire stream, in many instances, is turned into one row at a time and allowed to fill the furrow (actually a triangular-section basin 20 to 40 ft in length and 5 ft wide) to within a few inches of the top. The base of the cane planted in the bottom of the furrow is completely submerged by each irrigation during the first few weeks after planting. As cane grows larger, it offers quite an impediment to flow of water, but the water is still applied in the same manner and the base of the stock, which is planted in the bottom of the furrow, is completely surrounded by water.

There seems to be a general feeling among irrigators that the water will not move laterally through the soil for any significant distance and the cane must, therefore, be surrounded with water in order to be adequately irrigated. Actually many of the Puerto Rican lands have a tight subsoil and good structure in the silt loam or silty clay surface, which is a favorable combination for lateral spreading of water in the soil. The authors have observed that lateral spreading normally soaks the entire soil between furrows.

When the McLane distribution method was first adopted, years ago, there was a feeling that it was superior to other methods in economy of application and in uniformity of distribution. This belief is not borne out by facts. Preliminary data now being collected show that 50 to 70 per cent of the water delivered to the field is often wasted through deep percolation. The volume of water applied in a single irrigation is sometimes in excess of 20 acre-inches per acre. Distribution costs are extremely high. Irrigators using this method of distribution often irrigate less than one-half acre per man per day.

(Continued on page 48)

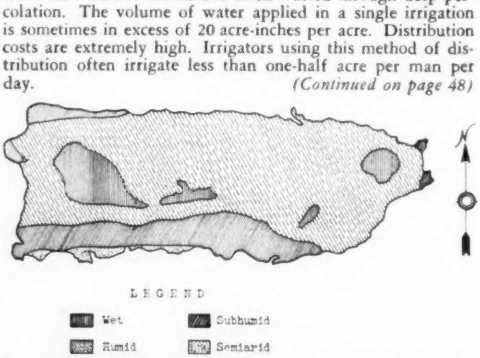


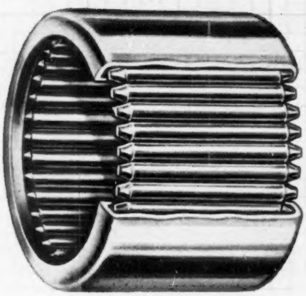
Fig. 1 Climatic map of Puerto Rico according to the Thornthwaite system of classification (adapted from "Climate and Man", yearbook of Agriculture (USDA), 1941, page 222)

This paper was prepared expressly for AGRICULTURAL ENGINEERING and is a cooperative contribution of the Puerto Rico Agricultural Experiment Station at Rio Piedras, Puerto Rico, and the Research Division of the Soil Conservation Service and the Bureau of Plant Industry, Soils and Agricultural Engineering, U. S. Department of Agriculture.

The authors: D. K. FUHRIMAN and R. M. SMITH, respectively, former agricultural engineer and present project supervisor of the cooperative project, "Erosion Control & Stable Crop Production in Puerto Rico".

* 1947 population — data from "Statistics of Puerto Rico" — 1946-47 fiscal report, Puerto Rico Department of Agriculture and Commerce.


TORRINGTON NEEDLE BEARINGS
stand up
in rugged service



The cultivation practices which are used along with the distribution system are not conducive to high irrigation efficiency. Aside from the fact that the cane is growing in the bottom of the furrow, cultivation of the cane as growth progresses is intended to break down the ridge between the rows, throwing the soil against the stalks. It is believed that this is necessary for the proper growth of the cane, but there is no proof. In fact cane is known to grow well on some of the upland areas of Puerto Rico and on other Caribbean islands without the movement of soil to the stalks.

In any case, the practice causes serious difficulties to the irrigator in his efforts to keep the water confined to the channel and under control. As the season progresses, the ridge gets smaller and the furrows fill up. After the system has been in use several months, the banks of the supply ditch must be raised in order to get the water into the furrows. This results in considerable waste of water and labor because of the increased difficulty of control.

The best that can be said for this system is that its closely spaced field ditches obviate the necessity of extensive land-leveling operations so important in most methods of surface distribution of irrigation water. Another asserted advantage of doubtful value to the individual farmer, but nonetheless important to Puerto Rico, is the greater use of the over-abundant labor supply.

Improvements. A few plantations have modified the standard method of surface distribution. Usually the modification is to increase the distance between McLanes, making a longer furrow, but not changing the basic methods. This modification alone is of little value without changing the methods of controlling and distributing the water to the field. The use of a larger quantity of water by each irrigator with distribution into a number of furrows at once, or the use of control gates, siphons, or spiles in the furrows, would materially improve the present practices. This is now being done on at least one plantation with considerable success in spite of the opposition toward change on the part of the irrigators and supervisory field men. The improved practice is being carried out with little change in the basic cultivation system or layout design, but, even so, it has been found that one man, using pipe spiles or siphons, can irrigate more than 5 acres per day (Fig. 6). Some difficulties have been experienced under this improved practice because of the fact that the cultivation system has not been changed. It will be noted in the field shown in Fig. 6 that the cane is still planted in the bottom of the furrow. Cultivation of these fields fills up the furrows and seriously hinders the water distribution as the growth of the crop progresses. It is difficult to change any details of the irrigation procedures without working out a complete revision of the accepted methods of land preparation, planting, cultivation, and harvesting.

Sprinkling Improvements Needed. Sprinkling systems have been used successfully on some lands in Puerto Rico. Many of the sprinkling systems in use have not been properly designed and are, therefore, not operating at peak efficiency or economy. In fact, some are giving poor distribution because the pump is too large, the pipe is too small, the nozzles are too large or of improper design, or the nozzles are incorrectly located for proper coverage.

An example of the way some of these systems have come into existence is shown by the recent case where a farmer obtained a second-hand pump and motor, then decided to irrigate some of his land. He had no concept of volume of water or rates of flow required. He decided to use perforated pipe and so bought several hundred feet of wrought iron pipe and began drilling it in a haphazard *(Continued on page 50)*

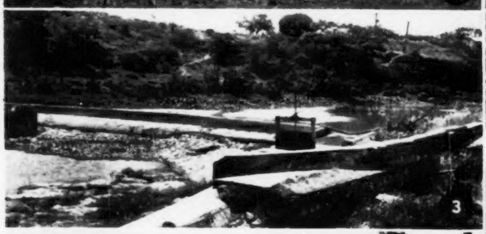
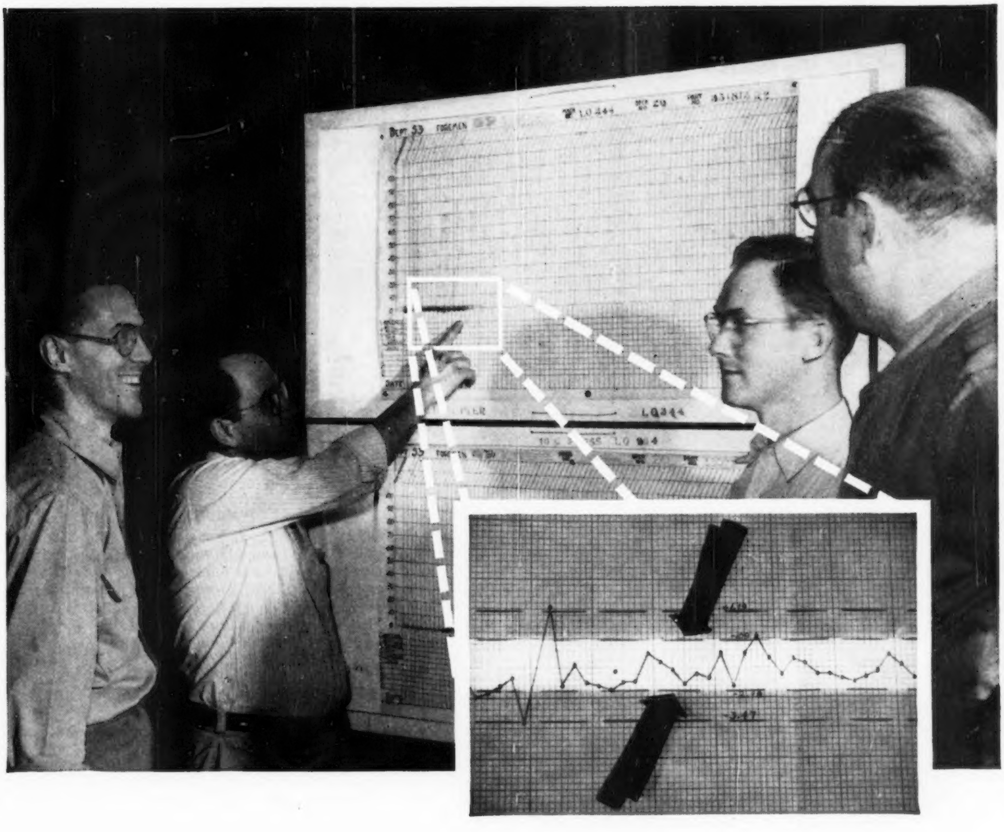


Fig. 2 This rock masonry irrigation flume is a reminder of the Spanish era prior to 1898. Flume is in a recently harvested sugarcane field near Ponce on Puerto Rico's south coastal plain. It is elevated about 8 ft above the ground and carries about 3 sec-ft of water • Fig. 3 An old diversion dam still in use near Coamo shows recent repairs to the original structure. Note that the brick wing wall in foreground has been raised by a rock masonry "topping". Crest of dam has been raised by the addition of concrete • Fig. 4 One of the closed conduits which branch out from either side of the diversion dam shown in Fig. 3. This conduit was originally constructed of brick masonry and has since been repaired with concrete. The standpipes shown are spaced about 200 ft apart and have no known purpose except to provide access to the conduit for cleaning and repair • Fig. 5 An irrigator bringing water to a cane field using the McLane system. McLanes here are spaced 40 ft apart and carry water to the individual furrows. The irrigator is at one McLane and the camera at an adjacent one. Note that all of the water is turned into one furrow, and the base of the young cane stalks are submerged in several inches of water. Pile of cane trash in foreground is from previous crop • Fig. 6 Concrete pipe spiles are used to provide better control of the irrigation water on a few isolated fields. Note that cane is growing in furrow bottom. Field laterals are spaced about 250 ft apart here, representing a radical change from general distribution system. Lack of change in cultivation method has caused some difficulty in distribution despite the fact that furrow slope is about 2 per cent



How lines on a chart safeguard IH quality

A report to you about men and machines that help maintain International Harvester leadership

Portrait of Near Perfection. IH engineers like the looks of this graph. It tells a story of controlled quality. The location of each dot represents the measurement of an International Harvester part that is being mass-produced.

As long as most of the dots fall between the narrow limits set by IH engineers, all is well. But if too many dots appear above or below the established limits, the engineers stop production until the trouble is found and remedied.

These quality control charts are an ever-present check on men, machines, and materials—a constant incentive to do a better job. They help prevent errors before they occur. Plant-wide quality control is another reason for IH leadership. International Harvester Company, Chicago 1, Illinois.

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fashion full of ¼-in holes. Needless to say, he spent considerable sum of money and got practically nothing in return.

Commercial irrigation sprinkling equipment distributors could greatly improve this situation by having more trained engineering representatives in the field to acquaint the farmers with basic design requirements. Actually most of the farmers using even these poorly laid out sprinkling systems do not realize that they are usually operating under less than optimum conditions and are well pleased at the contrast between their sprinkling system and the furrow methods being used in most of Puerto Rico. The greatest advantage from sprinkling is being realized on the sloping or rolling irregular topography.

Efficient Use of Water an Urgent Need. Puerto Rico's water distribution methods are quite different from those of irrigated areas of the western United States. The basic problem of economical distribution and efficient use of the water supply, however, is not unique. It is more pressing in Puerto Rico than in many areas because of the high cost of developing additional supplies. Reservoir sites are scarce and construction is expensive. Table 1 shows that the cost of providing storage in Puerto Rico is considerably higher than in the Continental United States. Furthermore, many of the existing reservoirs in Puerto Rico are silting rapidly. For example, Coamo Reservoir, built in 1914 with a capacity of 2827 acre-feet, now stores only about 400 acre-feet. Guayabal Reservoir, built the same year, has had its capacity decreased from 9580 to about 4700 acre-feet. The rate of silting is greater than in most of the reservoirs in the United States. This fact, added to the high cost of construction per acre-foot of stored water, makes the problem of efficient distribution and use of the existing water supplies extremely important.

TABLE 1. COST OF RESERVOIR STORAGE CAPACITY*

Reservoir	Storage capacity, acre-feet	Cost per acre-foot of capacity, dollars†
U. S. Reservoirs		
Hoover (Lake Mead)	30,500,000	5.4
Grand Coulee	10,000,000	39.4
American Falls	1,700,000	1.8
Owyhee	715,000	9.4
Shoshone	456,000	30.7
Arrowrock	280,000	15.4
Deer Creek	145,000	22.5
Gibson	105,000	22.0
Stoney Gorge	50,200	20.9
Pineview	44,200	79.0
Moon Lake	30,000	48.0
Hyrum	15,300	61.0
Puerto Rico Reservoirs		
Guajataca	33,800	40.8
Guayo‡	13,850	226.0
Yauco‡	13,200	227.0
Patillas	12,806	132.0
Guayabal	9,580	86.0
Carite	9,537	37.0
Coamo	2,827	133.0

* Computed from data furnished by Planning Section, Puerto Rico Water Resources Authority, Annual Reports of the Governor of Puerto Rico, and miscellaneous published data of U. S. Bureau of Reclamation.

† It is noteworthy that cost data for the USBR projects in the United States are largely for construction during the 1930-40 period whereas the Puerto Rico projects which are already constructed were built in the 1910-14 period, except Guajataca which was completed in 1928. Costs therefore are not strictly comparative unless corrected for construction cost differences between the two periods.

‡ Approved but not yet constructed.

In recent years there has been considerable development of ground-water supplies which has helped in some areas to alleviate the problem of insufficient storage. Most of the ground water basins are probably being used to near capacity at present and any future development of any magnitude would have to include a recharge or water-spreading program to prevent sea water encroachment. A considerable area east of Ponce, on the south coast, has deep beds of gravel below the heavier textured soil and seems to provide an almost ideal situation for ground water storage. Studies are needed to determine how much additional water could be efficiently put into and recovered from these underground reservoirs.

Research Being Carried Out. Studies are now in progress to determine the efficiency of water application under methods used in Puerto Rico, and to determine actual water requirements of cane and other crops under existing conditions. Results of these studies should assist in a more intelligent utilization of Puerto Rico's water resources.

Future water development for Puerto Rico will be more costly than existing supplies. It is, therefore, increasingly important that irrigation water be distributed efficiently and used intelligently. Progress in this direction will stabilize and increase the scope and permanence of Puerto Rico's irrigated agriculture.

Engineered Rice Drying

(Continued from page 45)

Perhaps in conclusion some mention should be made of milling quality and the standard used to measure changes in milling quality caused by the drying process. Apparently the milling quality factor most influenced by drying is pounds of head rice per barrel. Rice carefully harvested by hand and slowly air-dried at uniform atmospheric temperature under favorable conditions does not, however, yield 100 per cent head rice. Results on 18 samples each of Zenith, Caloro, Bluebonnet, and Rexoro, all hand-harvested and air dried for 30 days were as follows: Zenith averaged 86.8 per cent head rice with a standard deviation of 4.1 per cent and coefficient of variability of 4.8 per cent; Caloro, 85.6 per cent with a standard deviation of 5 per cent and coefficient of variability of 5.8 per cent; Bluebonnet, 63.7 per cent with a standard deviation of 9.8 per cent and coefficient of variaiblity of 15.4 per cent; and Rexoro, 62.8 per cent with a standard deviation of 2.3 per cent and coefficient of variability of 3.6 per cent. These results were obtained by an official inspector using a Smith shelling device. Differences in the above percentage do not necessarily mean that one variety will consistently yield a higher percentage of head rice than another variety, because of the influence of numerous other factors such as stage of maturity, fertility of soil and physical injury to the grains. By using air drying as a standard, a means is provided for making comparative studies. For example, this standard rice can be compared with identical lots of the same rice dried at different temperatures and humidities. Usually an artificially dried sample is of lower quality than air-dried samples. Occasionally there is, however, no decrease but even some increase in quality.

Complete records of the conditions under which all samples were dried are available. These data, and other data which will be supplied by agronomists, pathologists, physiologists, and others, will furnish guideposts which will lead to better rice drying in the future.

Engineering Progress

ENGINEERING progress has always been based on ingenuity, and engineering ingenuity exists in many forms. The adaptation of old ideas to new developments, the utilization, for new purposes, of old and familiar equipment, the practical application of new scientific discoveries to the needs of mankind—all these illustrate what I have called profit progress, because in all of them the accumulations of the profits of a free-enterprise system are called upon to make still further advances of progress and thus enhance engineering contributions to a peaceful world. This to me is the role of the engineers in a peaceful world. So long as engineers continue to display marked ability to find unique solutions to new problems, so long as their application of profit progress is not impeded by governmental restrictions, the parade of technical developments with their contributions to world peace will not fail in its forward movement toward a better economy and a growing cooperation with other freedom-loving peoples. —James M. Todd in *Mechanical Engineering* for January, 1950.

NEWS SECTION

Nominations for 1951-52 ASAE Officers

THE Nominating Committee of the American Society of Agricultural Engineers has placed in nomination the following members of the Society for the various elective offices to be held at the next annual election of officers to be conducted by letter ballot:

For President:

Stanley M. Madill, executive engineer, John Deere Waterloo Tractor Works of Deere & Company, Waterloo, Iowa.

For Vice-President:

Edwin L. Hansen, partner, Hansen Brothers Agricultural Engineering Sales and Service, Hillsdale, Ill.

James L. Strahan, technical director, Asphalt Roofing Industry Bureau, New York, N. Y.

For Councilor:

George D. Clyde, chief, division of irrigation, Soil Conservation Service, U.S. Department of Agriculture, Logan, Utah.

Howard Matson, chief, water conservation division (Region 4), Soil Conservation Service, U.S. Department of Agriculture, Fort Worth, Tex.

For Nominating Committee:

A. W. Farrall, head, agricultural engineering department, Michigan State College, East Lansing, Mich.

L. H. Ford, supervisor, parts catalogs and manuals, International Harvester Company, Chicago, Ill.

G. E. Henderson, coordinator, Southern Association of Agricultural Engineers and Vocational Agricultural Educators, Athens, Ga.

T. E. Hienton, head, division of farm electrification (BPISAE), U.S. Department of Agriculture, Beltsville, Md.

V. S. Peterson, manager, central west district, extension division, E. I. du Pont de Nemours & Co., Ames, Iowa.

W. W. Weir, drainage engineer, division of soils, University of California, Berkeley, Calif.

Agricultural Engineers on Critical Occupations List

AGRICULTURAL engineering is definitely included in the Critical Occupations List published by the U.S. Department of Labor, according to word recently received at the ASAE headquarters office from the Department.

Reported difficulty of some agricultural engineering students and recent graduates subject to selective service in obtaining appropriate consideration of this field by individual draft boards led to recommendations to the Department of Labor, to which it has replied in part as follows:

"Although the abbreviated index of titles on the first page of the Critical Occupations List does not include Agricultural Engineer by specific title, the occupation is included in the Critical List.

". . . the General Definition for *Engineer, Mechanical*, on page 14 of the Critical List states specifically 'This definition includes all job titles included in the Dictionary of Occupational Titles Code group 0-19. Illustrative of such job titles are Mechanical Engineer; Aeronautical Engineer; Agricultural Engineer; Marine Engineer; and Automotive Engineer.' Thus Agricultural Engineer is included as a critical occupation, although the Dictionary definition (page 11, Volume I, Second Edition, 1949) is not reprinted in the Critical List."

The letter further explains that the listing of engineers and branches of engineering in Volume II of the Dictionary was originally set up to "maintain statistical comparability with occupational groupings established by the Bureau of the Census. In preparing future revisions of the Dictionary, however, we will be glad to consider your recommendations to set up a new code group exclusively for the agricultural engineering field."

For reference this information is given in a letter dated December 4, 1950, file EPO, to ASAE headquarters, and signed by A. W. Motley, assistant director, Bureau of Employment Security, U.S. Department of Labor, Washington 25, D.C.

This is part of the group which attended the organization meeting of the ASAE Oklahoma Section

A.S.A.E. Meetings Calendar

January 26 and 27—PACIFIC COAST SECTION, Mayflower Hotel, Los Angeles, Calif.

February 5-7—SOUTHEAST SECTION, Peabody Hotel, Memphis, Tenn.

March 23 and 24—SOUTHWEST SECTION, Texarkana, Tex.

June 18-20—ANNUAL MEETING, Rice Hotel, Houston, Tex.

August 27-29—NORTH ATLANTIC SECTION, Shelfont-Haddon Hall Hotel, Atlantic City, N. J.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to A.S.A.E., St. Joseph, Michigan

ASAE Oklahoma Section Organized

THIRTY-FOUR ASAE members and men associated with agricultural engineering work in Oklahoma met at the Oklahoma Gas and Electric Company Hall in Oklahoma City, December 9, 1950, to organize the Oklahoma Section of the American Society of Agricultural Engineers. E. W. Schroeder acted as temporary chairman of the meeting. The program session included talks by C. A. Evans, M. B. Cox, and L. S. Terbush, on certain phases of soil and water conservation engineering work in Oklahoma; and talks by Louis Strong and Charles Bradford on rural electrification progress in Oklahoma. The newly organized section adopted by-laws and elected the following officers for a one-year term: Chairman, C. A. Bradford, agricultural engineer, Public Service Co. of Okla.; vice-chairman, M. B. Cox, associate agricultural engineer, Soil Conservation Service, USDA; and secretary, G. L. Nelson, associate professor of agricultural engineering, Oklahoma A. and M. College.

Personals of A.S.A.E Members

F. L. Aldred, agricultural engineer, division of rural housing and farm structures, USDA, has been called to active duty with the Army, but information as to his assignment is not available.

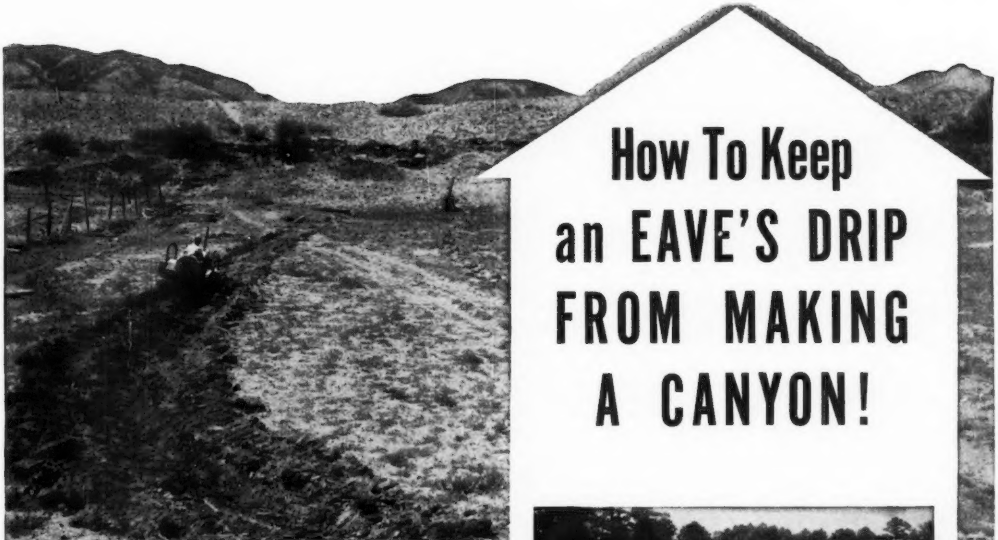
William L. Clark, vice-president, J. I. Case Co., who has had general supervision of domestic sales for the company for many years is being relieved of this responsibility at his own request. He continues as vice-president and director of the company, but in the future will serve in a consulting capacity and will be responsible for such matters as may be assigned to him. He has been in the service of the Case Company nearly 20 years. In 1940 he served as president of the Farm Equipment Institute.

Robert J. McCall, W. Kent Richey, and *Harold P. Twitchell* have recently purchased the agricultural division of the Howard S. Sterner Co., and are now operating as the New-Way Farm Sales, Inc., located at 16 North Harris Ave., Columbus, Ohio. Their business is a combination of consulting agricultural engineering and the sale of farm building equipment.

John S. Norton resigned his position as research associate in agricultural engineering at Louisiana State University, effective December 1, to join the engineering staff of Harry Hawthorne, Inc., manufacturers of grain drying, storage and elevator equipment, at Welch, La.

Elwood F. Olver, formerly assistant professor of agricultural engineering at Pennsylvania State College, recently accepted the position of educational director of the Iowa Rural Electric Cooperative Association, with headquarters at 1114 Register and Tribune Bldg., Des Moines, Ia.

Roy T. Tribble, agricultural engineer, Hawaii Agricultural Experiment Station, and secretary-treasurer of the Hawaii Section, ASAE, has recently received his orders to report for active duty with the Navy for an indefinite period of time. He will be assigned to a surface ship.



How To Keep an EAVE'S DRIP FROM MAKING A CANYON!

The answer is lead it gently down the slope to the creek, so it can't start a "wash". And Norman Eggleston, Salida, Colorado, shows just what equipment to use to do the job efficiently, at bottom cost!

His "Caterpillar" Diesel D2 Tractor equipped with No. 2A Bulldozer makes a diversion ditch to drain away, harmlessly, the run-off water from ranch buildings. In an hour, or so, and on a couple of gallons of non-premium Diesel fuel!

"Caterpillar" builds bulldozers to team with heavy-duty track-type tractors. "Caterpillar" dozer blades are shaped and reinforced to give earth the famous live-action roll that produces top yardage. And an operator learns to make this dozer "talk business" as readily as he acquires plow-savvy!

Farmers with dozers, and the all-weather power to push them, add extra profit seasons to their year — gain the means to do many effective conservation jobs, at home or for hire! Like grubbing hedge or brush, filling gullies, building ponds, fitting waterways for grassing, leveling, clearing stone, etc.

Legend has it that the drip from the eaves of a Georgia barn started this canyon, that has ruined several farms.

A remarkable percentage of "Caterpillar" Diesel Tractors purchased by farmers leave dealers' floors equipped with "Caterpillar" Bulldozers!

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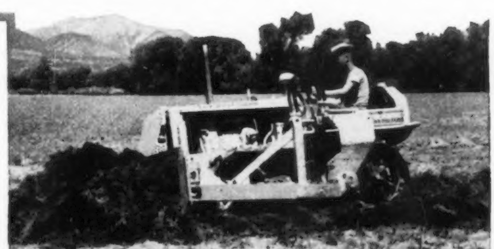

Making of a Design Engineer

(EDITOR'S NOTE: A college agricultural engineering department asked a farm equipment manufacturer just what they wanted a young graduate to know and do when accepting employment on the company's implement design staff. The chief engineer's reply to this inquiry will be of general interest, and we reproduce it here with his permission.)

THE question as to just what the farm equipment industry wants a young man to know and do when he joins a company's implement design staff has been a rather moot point with a good many men responsible for design in this industry. There are too many young men coming to us with hazy ideas as to what machine design actually means. From my own observations, more than half the graduates seeking employment indicate they would like to get into research or testing work which to them seems to have a certain glamour about it. Jobs in testing and field experimental work, in most companies, are in the minority. There is, however, always an opening for a man with ideas who also knows something about shop practice and design. This generally means that a young man coming to us should be a good draftsman. That is, he should be able to represent his ideas in the form of a drawing.

Relative to the strictly engineering subjects a young man needs, there is, first of all, the necessity for mastering the theory of elasticity. He should be able, without too much reference to handbooks, to make spring calculations. He should be familiar with the stress, strain, and deflection relationships in stressed machine parts. He should know what we mean by section modulus, moment of inertia, etc.

In dynamics, he should be able to handle problems of acceleration, such as flywheel designs, cam designs and vibration problems, without an older engineer having to spend time explaining basic principles to him. In statics, he must be familiar with the analysis of forces in complex machine structures.

A young man, on leaving school, should know something about gear design. To me, it is very irritating to have to point out to a young man what a stub-tooth gear is and why it is made a stub-tooth gear, and to have to explain to him common terms used in the industry.

A knowledge of engineering materials and their properties is highly essential. The effect of cold working on steels and their physical properties should be understood. Familiarity with iron-carbon diagram and fundamentals of Austenite transformation is necessary. Similarly, he should know the relationship between hardness and strength of steel, and he should be familiar with the common terms of metallurgy; for instance, what does "reduction of area" mean and how is it expressed?

With respect to shop practice, a young man beginning work should have a knowledge of foundry practice and terms. It is well if, once in his life, he had to make a pattern and actually make a mold for it and pour liquid metal into it.

Knowledge of machine-tool and punch-press work and heat-treating procedures is quite essential. To work efficiently in a designing department, a man should know what tool design has to accomplish, and how the design of a part affects tooling cost.

The foregoing are just a few of the items in which I often find young men are lacking in fundamental knowledge. I can appreciate a young man's desire to get into interesting work, and I am sure a good many young men have ideas, but it is my observation that often we have to spend too much time teaching fundamental knowledge to recent graduates, knowledge that should have been put before them somewhere in school and which they should have mastered. A young man should not get the idea, because he has dealt with spring calculations, for instance, in his sophomore and junior years, that this is sufficient. The terms and procedures of what he has learned should be available to him readily and without too much reference to handbooks, or by some older man explaining them to him, or by too much brushing up.

I hope that the foregoing may present some of the difficulties engineering departments have with young graduates. In addition I would like to say that it is highly essential in a young engineer's education that he visit as many manufacturing plants as possible while he is still a student. I refer not only to the kind of plant in which he will eventually work, but also the basic processing industries as steel making, iron or steel foundries.

After some 20 years in design work in the farm equipment industry and watching numerous young men enter this work, my preference for an implement design engineer is a young man with actual farm background and good mechanical engineering training. There are a few agricultural engineering courses with a so-called mechanical option which turn out fairly acceptable engineers, if they have a natural inclination for design work. However, the majority of agricultural engineering courses I consider as entirely inadequate in furnishing us good men out of whom we can develop competent design engineers.

WM. VUTZ
Chief engineer,
New Idea Div., Avco. Mfg. Corp.

New Bulletins

Mechanization of American and German Agriculture, by Dr. C. H. Dencker, director, Institut fuer Landtechnik, Landwirtschaftlich Fakultaet, Universitaet Bonn, Bonn a Rh., Germany.

In the introduction to this bulletin, the author discusses briefly the different agricultural regions of the United States and then selects the New England states plus New York, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, and Michigan as the region which most nearly approaches prewar Germany. Charts are shown comparing the production relationships of several crops in four regions, the prices of grain and potatoes in the United States and Germany, price indices from 1910 to 1940 of the farmers' income and outgo, and the average income of industry and agriculture. Having spent some 6 months in the United States in 1931 studying American agriculture, the author makes comparisons of the then agricultural technique with that of 1949 — the rise and decline in numbers of tractors and horses, respectively, the changes in prices of livestock, and then describes the various tractors and their field uses. How combines have increased and threshers declined in use is shown. The rainfall in New England and Germany is compared, as well as the temperature and relative humidity, particularly during the harvest months. Corn harvesting and haying equipment, the barn drier, beet lifter, harvester, and loader, is described and illustrated, as well as equipment for carrying on the work around the farmstead such as litter carriers and manure conveyors. A typical cattle barn arrangement is also shown. Progress made in farm electrification is brought out and a map shown giving the degree of electrification in the different states, telling how electricity is distributed and giving some of the uses.

Through mechanization the bulletin points out that more land has become available for growing food, and curves are furnished to indicate how net food production has increased and feed production decreased — food production having nearly doubled in the period 1920-1945; crop production in the different regions, use and prices of artificial fertilizers, and increase in milk production in the same years is compared. Tied in with it is the effect on the long-term plan by the Planning Commission of the various states in reducing row-crop acreage in favor of sod crops such as grasses and legumes.

Finally the bulletin discusses how German agriculture can profit from the American developments (machines and methods), but cautions against too strict adherence to American practices because of a variety of conditions in Germany which differ from those in the United States.

Progress Report, 1936-1948, division of field husbandry, soils and agricultural engineering, Central Experimental Farm, Ottawa, Canada. The publication covers the experimental and investigational work of the division for the 13-yr period from 1936-1948. Approximately one-third of the report is devoted to agricultural engineering, including a series of articles on farm power, tillage implements, cultivators and weeders, seeders and fertilizers, and sprayers and dusting equipment. A second group of papers covers harvesting and storage of hay and silage. Results of testing harvesting equipment for grain, sunflowers, soybeans, corn, peas, and potatoes; drainage and irrigation investigations; and use of haulage and miscellaneous equipment are also described. Meteorology, soil surveys, soil fertility investigations, crop sequence, cultural experiments, water erosion, pasture investigations, and weed control experiments are other subjects reviewed in this progress report.

Farm Refrigerated Apple Storage, by H. E. Gray. New York State College of Agriculture, Cornell Extension Bulletin 786 (October, 1950). A good analysis is made of the requirements of apple storages and recommendations are given for planning, constructing, and equipping adequate and efficient farm storages. A large portion of the bulletin is devoted to the construction and equipment of good storages. Other sections present information on the calculation of the refrigeration load, design of the air distribution system, and a check list of common troubles in refrigerated storage operation.

Contour Fencing, by H. M. Gitlin and W. H. Pomerene. Ohio Agricultural Experiment Station (Wooster) in cooperation with the U.S. Soil Conservation Service (Coshocton). Research Circular 5 (May, 1950). This bulletin gives information on how to build contour fences and points out that they are both satisfactory and practical. As a guide in building a fence on a curve, recommendations are given for spacing of line posts, setting posts, placing wire and stretching the wire.

Fruit Sizing and Grading Machinery. National Institute of Agricultural Engineering (Wrest Park, Silso, Beds., England) (June 1950). This is a report of an investigation to determine practical throughput, accuracy of sizing, and extent of damage to fruit during grading.

(Continued on page 60)

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Adkins, Clarence S., Jr.—Partner in mining gravel and agr. limestone, Coushatta, La.

Ahrano, Frederick W.—Consulting agr. engr., president, Ahrano, Inc., 205 S.E. 7th St., Gainesville, Fla.

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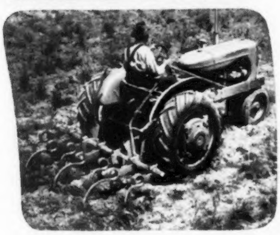

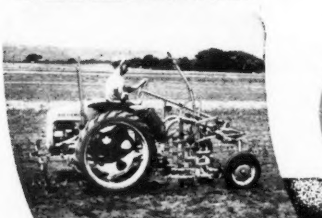

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TRANSFERS OF MEMBERSHIP GRADE

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NEW BOOKS

WATER, LAND, AND PEOPLE, by Bernard Frank and Anthony Netboy. Cloth, xviii + 331 pages, 5½ x 8½ inches. Illustrated and indexed. Alfred A. Knopf (New York) and McClelland and Stewart, Ltd. (Canada). $4.00.

Most people may agree with the basic thesis of the authors, that our population growth strongly suggests the need of more careful and complete husbanding of the land and water resources on which it subsists than has been practiced in the past. To be more than a reiteration of accepted principles, however, their book necessarily invades the highly controversial discussion of ways and means. In doing so, it cannot begin to review and consider all of the evidence bearing on the subject. Consequently, other authorities will undoubtedly take exception to various parts of their work, their selection of examples, their interpretations of examples presented, their viewpoint, conclusions, and recommendations as to action desirable in various major watersheds. Their material is organized into three parts covering the problems, the cost, and the solutions.

ARC WELDING LESSONS FOR SCHOOL AND FARM SHOP, by Harold L. Kugler. Leatherette, xi + 343 pages, 6 x 9 inches. Illustrated and indexed. The James F. Lincoln Arc Welding Foundation (Cleveland 1, Ohio). $1.00 in U.S.A., $1.50 elsewhere.

This is presented as a basic reference guide to practice for developing skills in using arc welding equipment, and to supply a need for basic instruction material for teaching welding to vocational-agriculture students at the high school level. It is also suitable for use in college agricultural engineering shop mechanics courses and as a guide in farm shop welding practice.

The book contains 8 informational lessons providing general information on welding, 17 operational lessons intended to teach arc welding skills, over 75 welded shop projects and an illustrated glossary.

The 8 informational lessons cover such subjects as progress in arc welding, controlling distortion, selecting welding electrodes, protecting health through safe practices, etc.

Part II covering the operational lessons includes such subjects as striking an arc and running a flat bead, butt welding in flat position, welding in overhead position, welding sheet metal, welding cast iron, building up worn parts, shaping—bending—and forming metal with the carbon arc torch, hard-facing with arc welding equipment, et cetera.

HANDBOOK OF MOLDED AND EXTRUDED RUBBER (First Edition). Cloth IX + 140 pages, 8½ x 11 inches. Illustrated and indexed. The Goodyear Tire and Rubber Co. (Akron 16, Ohio). No price stated.

This handbook has been published "to bring about a better understanding of the properties of rubber, with particular emphasis on the applications of these properties to the products generally known as 'molded goods' and 'extruded goods'." It is further indicated to approach the subject "from the standpoint of the engineer requiring a reference work to guide his preliminary design." Separate sections cover types of rubber and processing methods, rubber as an engineering material, stress-strain relationship in rubber, rubber in tension, rubber in compression, rubber in shear, rubber in vibration, specific properties and tests of rubber, and index and references.

New Bulletins

An Electric Fan Ventilation System for Dairy Stables, by C. G. Burress and D. C. Sprague. Special Circular 2 (October 1950) Pennsylvania State College (State College).

This summarizes briefly latest recommendations of the agricultural engineering department as to air requirements, method of supplying air, fan location, thermostat location, multiple fans, exhaust fan and equipment specifications, building heat losses, fresh air by infiltration, and management of the ventilating system. Their recommendation of 200-cfm capacity per 1000 lb of animal weight represents an upward revision from previous figures.

Electricity on Farms in the Eastern Livestock Area of Iowa, by Joe F. Davis and Paul E. Strickler. Circular No. 852 (September 1950), Bureau of Agricultural Economics, U.S. Department of Agriculture, in cooperation with the Iowa Agricultural Experiment Station. Reports on studies of a random sample of farms in the area as to growth of farm electrification; use of electricity on farms of various sizes, types, and incomes; labor savings; and indicated future use. Based on the indicated trend, the authors point to a probable average annual use of over 4500 kw hr per farm in this area by 1960, or more than double the use recorded for 1947.

Some Practical Considerations in Attic Fan Design: Part I. Housings, by W. D. Scoates. Texas Engineering Experiment Station (College Station) Research Report No. 13, May, 1950. Influences of entrance bells, increased pressures, relative positions of blade and drive, and position of blade in orifice, on performance and production of noise.

(Continued on page 62)

material handling *Magic!*

PRACTICALLY every farmer works on hundreds of different jobs in the course of one year. When you analyze these jobs you'll find a common denominator . . . they all involve *handling material* of one kind or another.

For field work most farms are fairly well mechanized. The forked stick, hand hoe, cradle and flail have been replaced with plows, cultivators, combines and dozens of other implements—in most cases tractor-powered. Thus the "handling" of soil and crops is accomplished by what may be described as "modern" methods.

But this is not true of chore work, of work around the farmyard, and of dozens of odd jobs that farmers must do each year. Here you'll find all too many farmers still use such "implements" as—shovels and forks, pails and wheelbarrows, bags and baskets, ropes and pulleys.

What a difference on many Ford Tractor farms—thanks to this tractor and the exceptional line of Dearborn Material Handling Implements. The "central figures" in this line are Dearborn Loaders, one model of which is pictured here. It can be equipped with a 16-foot lift crane which will handle all sorts of heavy material; or a 9-cubic foot material bucket; or a manure fork that holds about 10 cubic feet. Whatever the load, hydraulics lift it, not muscles! What a burden it takes off the farmer's back! What a revolution it can accomplish in farm maintenance and farm improvement projects!

This is a really tremendous story . . . to get complete details we suggest you see your nearby Ford Tractor dealer.

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MEANS LESS WORK . . . MORE INCOME PER ACRE

Ford TRACTOR

New Bulletins

(*Continued from page 60*)

Essential Considerations in Mechanization of Farming, by Allen S. Gordon, agricultural machinery officer, Food and Agriculture Organization of the United Nations. FAO Development Paper No. 5 (June 1950), FAO, UN (Washington, D.C.) This reviews, for the information of the countries in which farm mechanization is less advanced than in the United States, the reasons for farm mechanization, factors determining feasibility of mechanization, ownership and use of mechanized equipment, types of machinery and equipment, maintenance and servicing of equipment, and government services for developing use of farm machinery.

Engineering Experiment Station News. Ohio State University, vol. 22, no. 4 (October, 1950). This issue is devoted to developments in the Ohio ceramics industry. It is pointed out how the engineer and associated technicians are becoming more important figures in every plant. Through mechanization, pottery making is becoming more of an industry and less of a craft. One indication of the strength of the American dinnerware industry is the amazingly low price of dinnerware in today's high priced market. Individual articles describe control methods, hydraulics, plastic pressing, drying, and modern equipment and practices in the ceramic industry.

Equipment for Electric Radiant House Heating. Technical Standards Division, REA, USDA (Washington, D.C.) (January, 1950). A ten-page digest of information on radiant heating equipment and costs compared to other methods of heating.

Manufacturers Freezer Specifications. Technical Standards Division, REA, USDA (Washington, D.C.) (May, 1950). A six-page tabulation of specifications on principal makes of freezer cabinets in the capacity range from 4 to 100 cu ft.

Abstracts on Crop Conditioning. Electro-Agriculture Section, Technical Standards Division, REA, USDA (August, 1950). A total of 144 abstracts on items applicable to 18 major crops.

Electric Home Pasteurizers for Milk and Cream. Technical Standards Division, REA, USDA. (August, 1950). Brief information on the value of this equipment to those depending on milk and cream not otherwise pasteurized, and on equipment available.

Electric Water Heater Investigation. Technical Standards Division, REA, USDA (1949). Final report on a survey of water heater use on farms in a selected area.

NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

New IH Stubble Carrier. With the new International Harvester Co.'s hydraulically controlled high-clearance stubble carrier shown in this picture, and a variety of teeth and sweeps and stiff or coil shanks available for use with it, grain farmers can cultivate stubble land thoroughly without turning it over or burying residues. Keeping the trash on the surface gives protection from wind and soil erosion. The high-clearance coil shank clamp has a built-in reinforcement for holding power and stability. Adjustments may also be made with this clamp for low-clearance cultivation and for use with subsoilers, stiff shanks, ditchers, middlebusters, and any other type of ground tool that can be clamped to a 2 or 2¼-in toolbar.

The new International Harvester high-clearance stubble carrier

PROFESSIONAL DIRECTORY

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated:

POSITIONS OPEN: JUNE—O-355-717, 393-719. JULY—O-360-722. AUGUST—O-25-503, 25-504. SEPTEMBER—O-34-506. OCTOBER—O-75-507, 76-508, 46-509. NOVEMBER—O-102-510, 108-512, 108-513. DECEMBER—O-113-514.

POSITIONS WANTED: JUNE—W-364-393, 387-399, 274-400. JULY—W-337-409, 398-411, 412-413, 417-415. AUGUST—W-5-1, 4-2. SEPTEMBER—W-38-9, 40-10. OCTOBER—W-66-12, 69-13, 73-14, 71-15. NOVEMBER—W-93-16, 72-17, 99-18, 80-19, 109-20. DECEMBER—W-81-21, 114-22, 117-23.

NEW POSITIONS OPEN

RESEARCH ASSOCIATE for work in farm structures in an agricultural experiment station in the South Central area. Particular attention will be given to utilization of farm by-products and stabilized earth in farm structures. MS deg in agricultural engineering, or equivalent, completed or nearly completed. Research or commercial development experience in farm structures or structural materials desirable. Usual personal qualifications for public service research. Man with initiative will find opportunity to work on many of his own ideas. Project has been under way 2½ years. Salary, $3500-4500, on 12-mo basis, with 30 days vacation. O-141-515

NEW POSITIONS WANTED

DESIGN, development , sales, or service, in power and machinery or soil and water field, in private industry or public service. Southwest or East Coast location preferred. BS deg in agriculture, major in agricultural engineering, September 1950. University of Florida. Mechanical engineering background. Experience and training in surveying, construction and power equipment. War enlisted and commissioned (pilot) service in Air Corps, 3 years. Married. Age 25. No disability. Available on reasonable notice. Salary open. W-106-24

TEACHING or research in power and machinery or soil and water field, with college, federal or manufacturing organization, anywhere in U.S.A., preferably South. BS and MS (expected) degs in agricultural engineering, 1950 and 51, Louisiana State University. Experience as merchant seaman, postal clerk and U.S. storekeeper-gauger (at industrial alcohol plants). U.S. Coast Guard 3 years. One year of teaching experience by June 1951. Married. Age 39. No disability. Available in June. Salary open. W-140-25

DESIGN, development, or research in power and machinery or farm structures field, with experiment station or manufacturer, anywhere in U.S.A. BS deg in agricultural engineering expected in February, University of Missouri. Farm background. Three summers with Missouri State Highway Department as inspector, grade II. One year with Leach Hatcheries, Inc. One-half year in research, University of Missouri. War service in Army 2 years. Married. Age 27. No disability. Available February 1. Salary open. W-135-26

DESIGN, development, or research in farm structures, with manufacturer or public service agency, preferably in South or South Central area. BS deg in agricultural engineering 1949, University of Missouri. MS deg in agricultural engineering expected February 1951. Farm background. Precollege experience in pipefitting, 2 years. War enlisted service in Army as heavy equipment operator, 3 years. Undergraduate assistant working part time 18 months on SCS on hydrologic records, soil sample tests, etc. Graduate research assistant nearly 2 years, mostly on oil-fired circulating heaters. Married. Age 28. No disability. Available February 1. Salary $4000+. W-145-27

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